INSTRUCTION MANUAL

Type 1346
Audio-Frequency
Microvolter

A

GENERAL RADIO

Contents

WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

Type 1346 Audio-Frequency Microvolter

A

West Concord, Massachusetts U. S. A. 01781
Form 1346-0100-A
October, 1968
ID-0100

Specifications

Function	*10 V ac*	*1 V ac*	*+10 V dc −10 V dc*	*Atten Only*
Open-Circuit Output Voltage	1.0 μV to 10 V ac	0.1 μV to 1.0 V ac	1.0 μV to 10 V dc	0 to −120 dB 20 dB/step
Accuracy at 23°C (above 10% of dc full scale)	±(4%+0.2μV)	±(4%+0.02μV) 10 Hz to 100 kHz	±(3%+0.2 μV)	±(0.04 dB/step +154 dB below input level) dc to 100 kHz
Source	External ac required		Internal battery or ext dc source 10 V max	Ext ac or dc source 10 V max input
	10.0 V into 595 Ω	1.0 V into 550 Ω		
Input Impedance (approx)*	595 Ω to 25 kΩ	550 Ω to 25 kΩ	610 Ω to 25 kΩ with int battery removed	550 Ω to 5 kΩ

* Input impedance varies as shown in table with setting of input level control. Can be adjusted to remain constant when varying the step attenuator for load impedance of ≥50 Ω.

Distortion (at 1 kHz): <0.01% in 1-V ac mode, <0.05% in 10-V-ac mode, with level control at max setting.
Output Impedance: 600Ω ±0.5%.
Power Required: None required for 10-V ac range. In other modes, 12-V dry battery: Eveready 228, RCA VS329, or Burgess PM8. Approx life, 33 hours at 2h/day in either dc mode, 316 hours at 2h/day in 1-V ac mode.
Mounting: Convertible-Bench Cabinet.
Accessories Supplied: Battery; mounting hardware with rack model.
Accessories Available: GR 1309-A and 1310-A Oscillators, 1396-B Tone-Burst Generator, 1381 and 1382 Random-Noise Generators.
Dimensions (w x h x d): Bench, 8½ x 7½ x 7½ in. (220 x 190 x 190 mm); rack, 19 x 6 x 7⅝ in. (485 x 155 x 195 mm).
Weight: Net, 5¼ lb (2.4 kg); shipping, 9 lb (4.1 kg).

Catalog Number	*Description*
	1346 Audio-Frequency Microvolter
1346-9700	Bench Model
1346-9701	Rack Model

See *General Radio Experimenter*, August-September 1968.

NOTE: This instrument is equipped with our new snap-on knob for added convenience and safety. Refer to the Service Section for details.

Condensed Operating Instructions

a. Set the METER FULL SCALE switch to the desired mode of operation, LEVEL control full ccw, and FULL SCALE OUTPUT VOLTAGE switch to the desired attenuation.

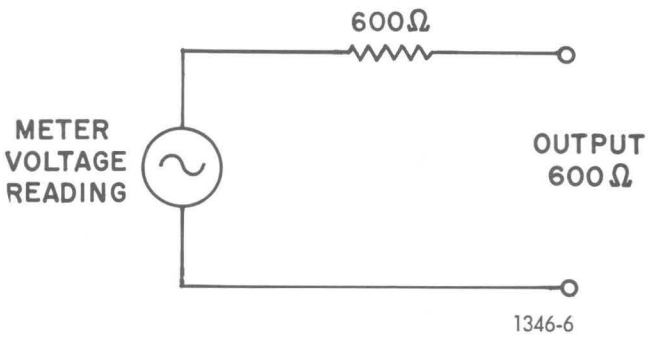
b. If in the 10-V AC, 1-V AC, or ATTEN ONLY mode, connect an appropriate signal source (10 V rms for 10-V AC and ATTEN ONLY modes; 1 V rms for 1-V AC mode) to the INPUT terminal(s), and connect the desired instrument to the OUTPUT terminal(s).

c. Set the OUTPUT ON- OFF switch to ON and adjust the LEVEL control for the desired meter reading.

The meter's full-scale range is indicated in green on the FULL SCALE OUTPUT VOLTAGE switch dial. For example, if the meter reads 5, and the switch dial shows 100 mV, the open-circuit output voltage is 50 mV.

The Microvolter's meter indicates open-circuit output voltage behind 600 Ω output impedance, as shown below. The internal output impedance must be taken into account with low-impedance loads.

Refer to Section 3 for details concerning the use of the meter's dBM scale.



Equivalent output impedance circuit.

Introduction–Section 1

1.1 PURPOSE.

The Type 1346 Audio-Frequency Microvolter * (Figure 1-1) is a metered, calibrated attenuator that can be used as a self-contained, low-level dc source, supplying positive and negative voltages from 1.0 μV to 10 V and, in conjunction with an appropriate oscillator, as a source of from 0.1 μV to 10 V of any ac waveform with a spectrum up to 100 kHz. The 1346 will convert almost any sine- or square-wave, noise, tone-burst, or other generator for operation as a calibrated-output source.

Use of the Microvolter converts an oscillator into a standard-signal generator, valuable in such measurements as gain or loss, frequency-response characteristics, overload level, and hum level on amplifiers, networks, and other audio-frequency equipment. The combination of oscillator and Microvolter is also useful in the measurement of the generated voltage of microphones, vibration and phono-graph pickups, and other transducers by the insert-voltage method.

The input to the 1346 can be a dc voltage from the instrument's internal battery (a readily available type) or from an external ac or dc source. An input attenuator provides continuous control of the voltage, and a meter indicates the output of the continuous attenuator, which is, in turn, applied to a 20-dB-per-step output attenuator. The two attenuators provide a total of 140 dB attenuation.

The meter is calibrated in ac volts, dc volts and dBm. The voltage scales are log volts, and the dBm scale is log dBm. The meter, in ac operation, is average-responding, and calibrated in rms volts. A panel switch selects one of five operating modes: 1 or 10 V ac full scale, +10 or -10 V dc full scale (providing for rapid polarity reversals), and attenuation-only, in which the 1346 acts only as a step attenuator without metering or a continuous level adjust-ment.

An on-off switch permits the output to be reduced to zero without disturbing other controls or short circuiting the output, maintaining the source impedance of 600 Ω; this is a convenience, especially at low voltage levels where shielding must be maintained. The zero-volt condition is of great value in incremental dc-gain measurements and in locating noise sources and ground loops in critical low-level measurements.

The Type 1346 is not line operated, permitting the instrument to "float" in a test setup where it may be necessary to add the output of the Microvolter to another signal.

1.2 DESCRIPTION.

The 1346 is assembled in a metal cabinet ready for bench use. A Rack Adaptor Set (P/N 0480-9723) is available for installation of the instrument in an EIA standard 19-inch-wide relay rack. The instrument has a 12-V internal battery for its circuit operation.

Front-panel binding-posts are gold-plated copper to keep thermal emf's (voltages) to a minimum, and alternate input and output connections are provided by rear-panel BNC connectors that help maintain shielding integrity and are convenient for permanent connection in rack-mounted assemblies.

Most of the instrument's circuit components, including four calibrating adjustments (see Section 5) are on one etched-circuit board. Other circuit components are on the front and rear panels. The battery is in a holder inside the instrument. These components are easily accessible by loosening the two captive screws on the rear of the instrument and removing the cabinet from the chassis.

*Trademark registered in U.S.A.

1.3 CONTROLS AND CONNECTORS.

Figure 1-1 shows the front-panel controls and connectors, and Table 1-1 contains a description of the controls and connectors. Table 1-2 contains a description of the rear-panel connectors.

The bottom terminal of binding-post pairs is grounded to the chassis.

1.4 ACCESSORIES SUPPLIED.

A 12-V dry-cell battery (Eveready 228, RCA VS 329, or Burgess PM8) is supplied with the instrument.

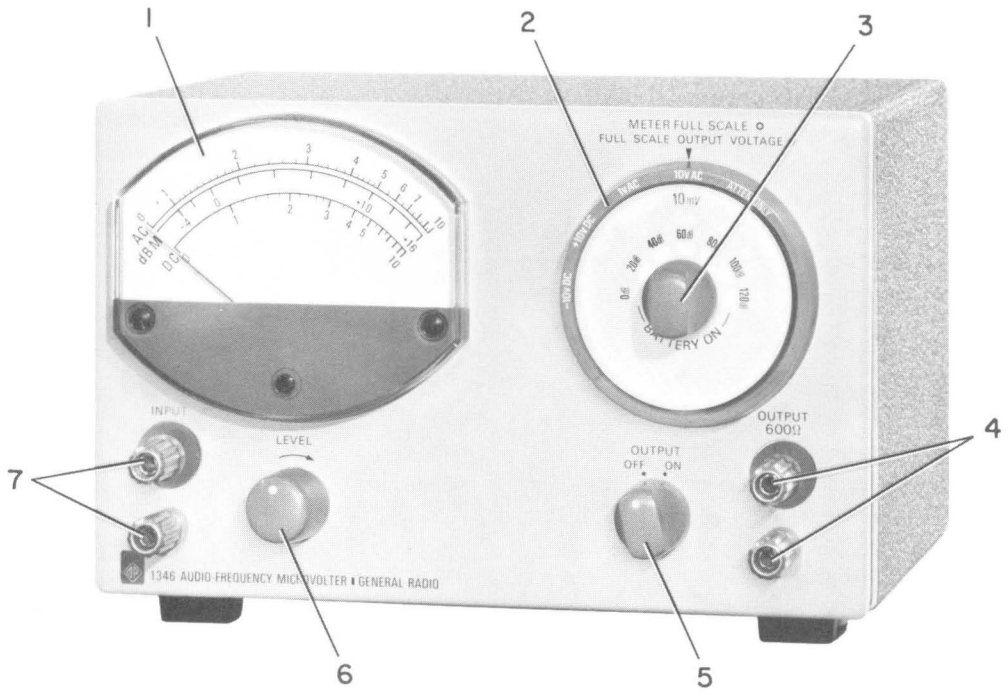


Figure 1-1. Type 1346 Audio-Frequency Microvolter.

Table 1-1
FRONT-PANEL CONTROLS, INDICATORS, AND CONNECTORS

Fig. 1-1 Ref. No.	Name	Type	Function
1	Level Meter	Meter	Indicates open-circuit output voltage and dBM. The meter full-scale sensitivity is determined by the settings of the METER FULL SCALE and FULL SCALE OUTPUT VOLTAGE switches and is indicated in green on the latter's dial.
2	METER FULL SCALE	Five-position rotary switch (outer concentric dial).	Selects the mode of operation (-10 V DC, +10 V DC, 1 V AC, 10 V AC, ATTEN ONLY) and, therefore, the voltage source connections and level-meter sensitivity. The ATTEN ONLY position connects the input signal directly to the 20-dB-per-step output attenuator, bypassing the level meter and LEVEL control.
3	FULL SCALE OUTPUT VOLTAGE	Seven-position rotary indicator-switch.	Selects output-signal attenuation in 20-dB steps and indicates in green the full-scale open-circuit output voltage. The BATTERY ON windows give a red indication when the internal battery is in use (±10-V DC and 1-V AC modes).
4	OUTPUT 600 Ω	Jack-top binding-post pair.	Output for the attenuated signal. The output impedance is 600 Ω; the lower terminal is grounded to the chassis.
5	OUTPUT ON-OFF	Two-position rotary switch.	Turns the output signal on and off, maintaining the 600-Ω output impedance. Although controlling the battery-source signal output, it does not turn-off the battery.
6	LEVEL	Continuous rotary control.	Level-meter deflection adjustment.
7	INPUT	Jack-top binding-post pair.	Input-signal connection. The bottom terminal is connected to chassis ground.

Table 1-2
REAR-PANEL CONNECTORS

Name	Type	Function
INPUT	BNC coaxial jack.	Alternate input-signal connector in parallel with the front-panel INPUT binding-post pair.
OUTPUT 600 Ω	BNC coaxial jack.	Alternate output-signal connector in parallel with the front-panel OUTPUT 600 Ω binding-post pair.

1.5 ACCESSORIES AVAILABLE.

Table 1-3 lists the accessories and related instruments available.

1.6 PATCH CORDS AND ADAPTORS.

The front-panel INPUT and OUTPUT 600 Ω connectors are standard, 3/4-in.-spaced pairs of binding posts that accept banana plugs, standard telephone tips, alligator clips, crocodile clips, spade terminals, and all wire sizes up to number 11 (Figure 1-2). The rear-panel INPUT and OUTPUT 600 Ω connectors are BNC jacks. A wide variety of GR patch cords (Table 2-2) is available, as well as adaptors to convert the terminals for use with most commercial and military coaxial connectors.

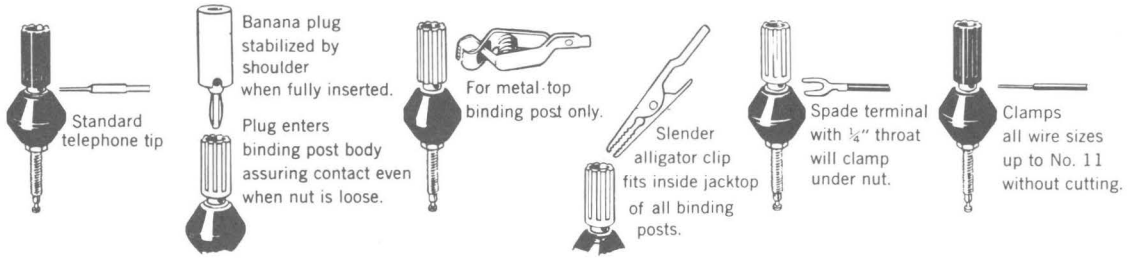


Figure 1-2. Methods of connection to the binding-post terminals.

Table 1-3
ACCESSORIES AND RELATED INSTRUMENTS AVAILABLE

Name	GR Type or Part No.	Function
Rack Adapter Set	P/N 0480-9723	Rack-mount instrument.
Coherent Decade Frequency Synthesizer (0 to 100 kHz, step or continuously adjustable)	Type 1161	Stable sine-wave signal source.
Oscillator (10 Hz to 100 kHz in four decade ranges, 5-V output, 60 dB step attenuator)	Type 1309	Sine- or square-wave signal source (low distortion, noise, and hum).
Oscillator (2 Hz to 2 MHz in 6 decade ranges, 20-V output)	Type 1310	Sine-wave signal source.
Audio Oscillator (50 Hz to 10 kHz in discrete frequencies. 1 W, 100-V or 4-A output)	Type 1311	Sine-wave signal source, transformer output.
Decade Oscillator (10 Hz to 1 MHz in five decade ranges, 20-V output, 80 dB step attenuator)	Type 1312	Sine-wave signal source.
Oscillator (10 Hz to 50 kHz in one range, 5-V output, 60 dB step attenuator)	Type 1313	Sine- or square-wave signal source.
Random Noise Generator		
(2 Hz to 2, 5, or 50 kHz)	Type 1381	Random-noise generator.
(20 Hz to 50 kHz)	Type 1382	Random-noise generator.
(20 Hz to 20 MHz)	Type 1383	Random-noise generator.
*Tone-Burst Generator	Type 1396	High-quality fast switch that alternately interrupts and passes sinusoidal, periodic, nonsinusoidal, or aperiodic signals.

*Panel size suitable for rack-mounting side-by-side with the 1346.

Installation–Section 2

2.1 INSTRUMENT LOCATION.

The instrument can be stored at an ambient temperature of -40° C (-57° F) to +70° C (159° F). For effects of temperature on operation, refer to Section 3. If the battery supplied with the instrument is not installed in the instrument, refer to paragraphs 5.5 and 5.12 for installation instructions.

2.2 DIMENSIONS.

Figure 2-1 is an outline drawing showing overall dimensions of the Type 1346 in bench and rack configurations.

2.3 BENCH MOUNTING.

To set the instrument in a tilted position, pull the bail between the front feet down as far as possible.

2.4 RACK MOUNTING.

2.4.1 Single Instrument.

With the Rack Adaptor Set, P/N 0480-9723, the 1346 portable bench model can be converted for use in an EIA standard 19-in. relay rack. Table 2-1 lists the parts included in the Rack Adaptor Set.

Mount the instrument as follows (see Figure 2-2):

a. Loosen the two captive 10/32 screws in the rear of the cabinet until the chassis is free; slide the chassis forward, out of the cabinet.

b. Remove the four rubber feet from the cabinet. Simply push out the two rear feet. Spread the bail (A, Figure 2-2) slightly and the two front feet (B) and the bail will drop out. Be sure to save all parts as they are removed for possible reconversion of the instrument to bench mounting.

c. Pierce and push out the plugs from the four bosses (C) on the inner sides of the cabinet, near the front.

d. Press the subpanel (D) into the blank panel (E) to form a support liner for the latter.

e. Attach the short flange of the blank panel to the front of the cabinet (on either side of the cabinet, as desired) using two 5/16-in. screws (F). Note that the screws enter in opposite directions–one from inside the cabinet and one from the flange side, as shown.

f. Pierce and push out the plug in the rear boss (G) *on the side toward the blank panel only*, as shown.

g. Attach one end of the support bracket (H) to the lower rear boss. The bracket must be placed so that the screw passes through a clearance hole into a tapped hole.

h. Attach the other end of the support bracket to the lower rear hole in the wide flange, as shown, using a 5/16-inch screw (K).

i. Attach one Rack-Adaptor Assembly (handle) to the side of the cabinet opposite the blank panel using two 5/16-inch screws (L). Again note that the screws enter in opposite directions, one from inside the cabinet and one from outside. Use the upper and lower holes in the assembly.

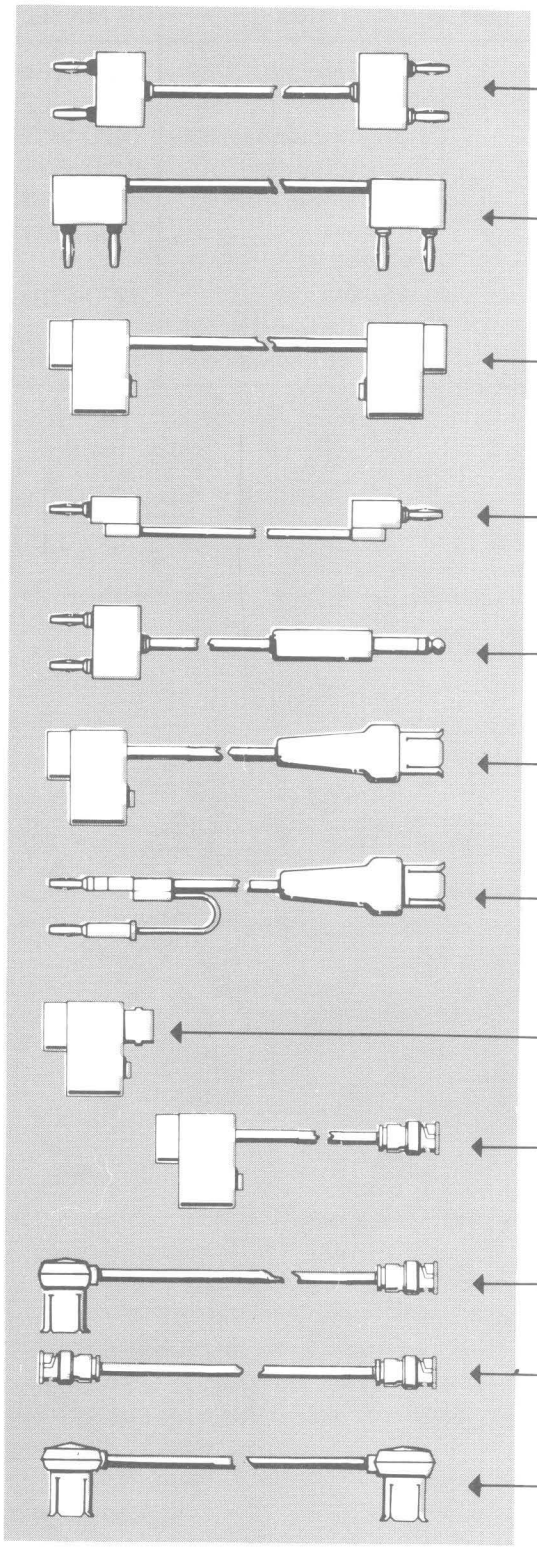
j. Attach the other Rack-Adaptor Assembly (handle) to the wide flange on liner (D) and the flange on the blank panel (E). Use two 5/16-inch screws (M) through the two flange holes nearest the panel and through the upper and lower holes in the handle. Again, the screws enter in the opposite directions.

k. Install the instrument in the cabinet and lock it in place with the two captive screws in the rear that were loosened in step a.

l. Place a straight edge across both the instrument panel and the blank panel. Loosen the screw (J) *through the slot* in the support bracket (H). Exert a slight pressure on the blank panel (E) so that it forms a straight line with the instrument panel, and tighten the screw (J) in the bracket to lock the panels in this position.

m. Slide the entire assembly into the relay rack and lock it in place with the four 9/16-inch screws (N) with captive nylon cup washers. Use two screws on each side and tighten them by inserting a screwdriver through the holes (P) in the handles.

Table 2-2
AVAILABLE INTERCONNECTION ACCESSORIES



TYPE NO.	DESCRIPTION	CATALOG NO.
274-NQ	Double-plug patch cord, in-line cord, 36" long	0274-9860
274-NQM	Double-plug patch cord, in-line cord, 24" long	0274-9896
274-NQS	Double-plug patch cord, in-line cord, 12" long	0274-9861
274-NP	Double-plug patch cord, right-angle cord, 36" long	0274-9880
274-NPM	Double-plug patch cord, right-angle cord, 24" long	0274-9892
274-NPS	Double-plug patch cord, right-angle cord, 12" long	0274-9852
274-NL	Shielded double-plug patch cord, 36" long	0274-9883
274-NLM	Shielded double-plug patch cord, 24" long	0274-9882
274-NLS	Shielded double-plug patch cord, 12" long	0274-9862
274-LLB	Single-plug patch cord, black, 36" long	0274-9468
274-LLR	Single-plug patch cord, red, 36" long	0274-9492
274-LMB	Single-plug patch cord, black, 24" long	0274-9847
274-LMR	Single-plug patch cord, red, 24" long	0274-9848
274-LSB	Single-plug patch cord, black, 12" long	0274-9849
274-LSR	Single-plug patch cord, red, 12" long	0274-9850
1560-P95	Adaptor cable, double-plug to telephone plug, 36"	1560-9695
874-R34	Coaxial patch cord, double plug to GR874, 36" long	0874-9692
874-R33	Coaxial patch cord, two plugs to GR874, 36" long	0874-9690
274-QBJ	Adaptor, shielded double plug to BNC jack	0274-9884
776-A	Patch cord, shielded double plug to BNC plug, 36" long	0776-9701
776-B	Patch cord, GR874 (right-angle) to BNC plug, 36" long	0776-9702
776-C	Patch cord, BNC plug to BNC plug, 36" long	0776-9703
776-D	GR874 to GR874, both right-angle, 36" long	0776-9704

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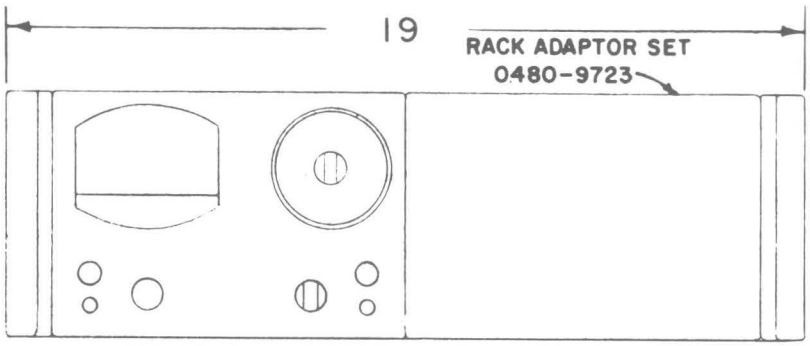
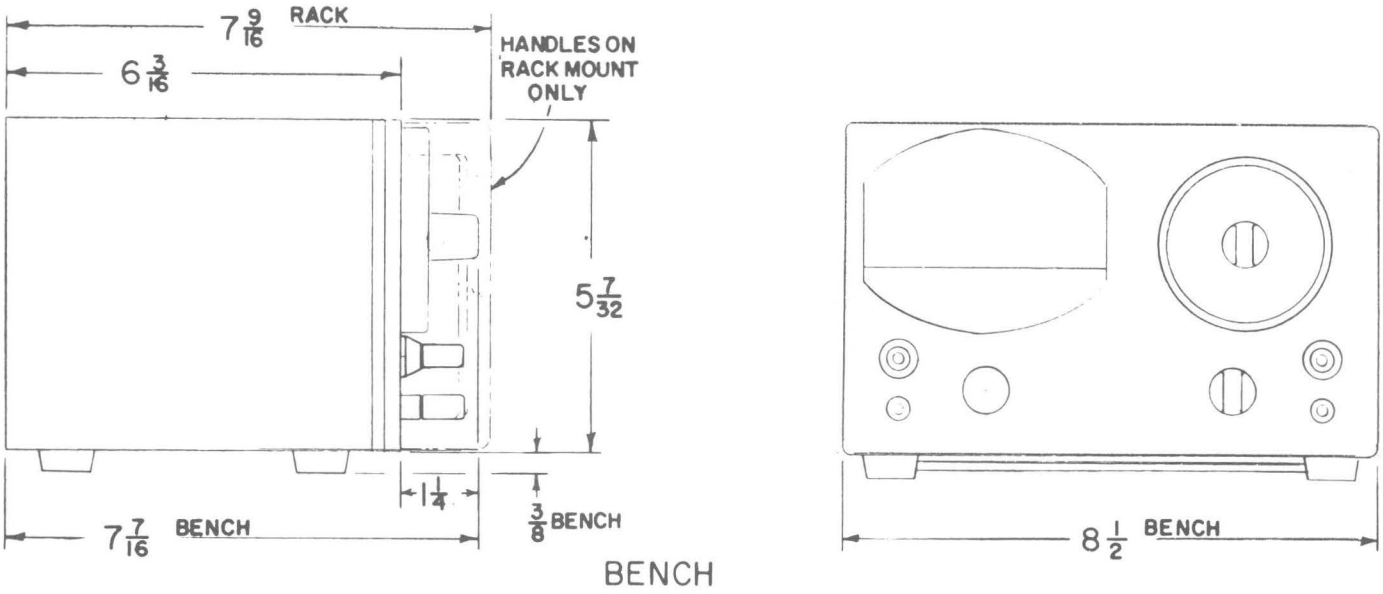


RACK MOUNT

DIMENSIONS IN INCHES



BENCH

Figure 2-1. Dimensions of the Microvolter bench and rack-mount units.

2.4.2 Reconversion to Bench Mounting.

a. To reconvert the instrument for bench use, reverse the procedures of paragraph 2.4.1 first removing the entire assembly of instrument, cabinet, and blank panel from the rack.

b. Remove:
1. Chassis from the cabinet.
2. Support bracket (H) from the cabinet.

c. Push the two rear feet into the cabinet, and slide the bail (A) and two front feet (B) into place. Install the instrument in its cabinet and lock it in place with the two captive screws through the rear panel.

2.4.3 Rack-Mounting Two Instruments.

Two instruments of the same panel size (such as two 1346's or instruments indicated in Table 1-3) can be mounted side-by-side in a standard 19-in. relay rack. Use the procedure of paragraph 2.4.1, substituting the second instrument for the blank panel. Do not use the support bracket (H, Figure 2-2), but insert three screws through the bosses in the adjacent sides of the cabinet, two near the front (C) and one near the rear (G). The four feet and the

bail must, of course, be removed from each cabinet. Use the four screws (N) with nylon washers to lock the instruments in the rack. The required hardware is:

1. Three screws, BH 10-32, 5/16 in., P/N 7080-0800.

2. Four screws, BH 10-32, 9/16 in., with nylon washers, P/N 7270-6310.

3. Blank panel (with handle attached) from one side of the cabinet.

4. Rack-Adaptor Set (handle) from the other side of the cabinet.

Table 2-1
PARTS INCLUDED IN THE RACK ADAPTOR SET, P/N 0480-9723 (see Figure 2-2)

Fig. 2-2 Ref.	No. Used	Item	GR Part No.
E	1	Blank Panel	0480-8933
D	1	Sub-Panel	0480-8952
—	2	Rack Adaptor Assembly	0480-4903
H	1	Support Bracket	0480-8524
—	1	Hardware Set includes	0480-3080
F,J,K,L,M, N		8 Screws, BH 10-32, 5/16"	7080-0800
		4 Screws, BH 10-32, 9/16" w. nylon cup washers	7270-6310

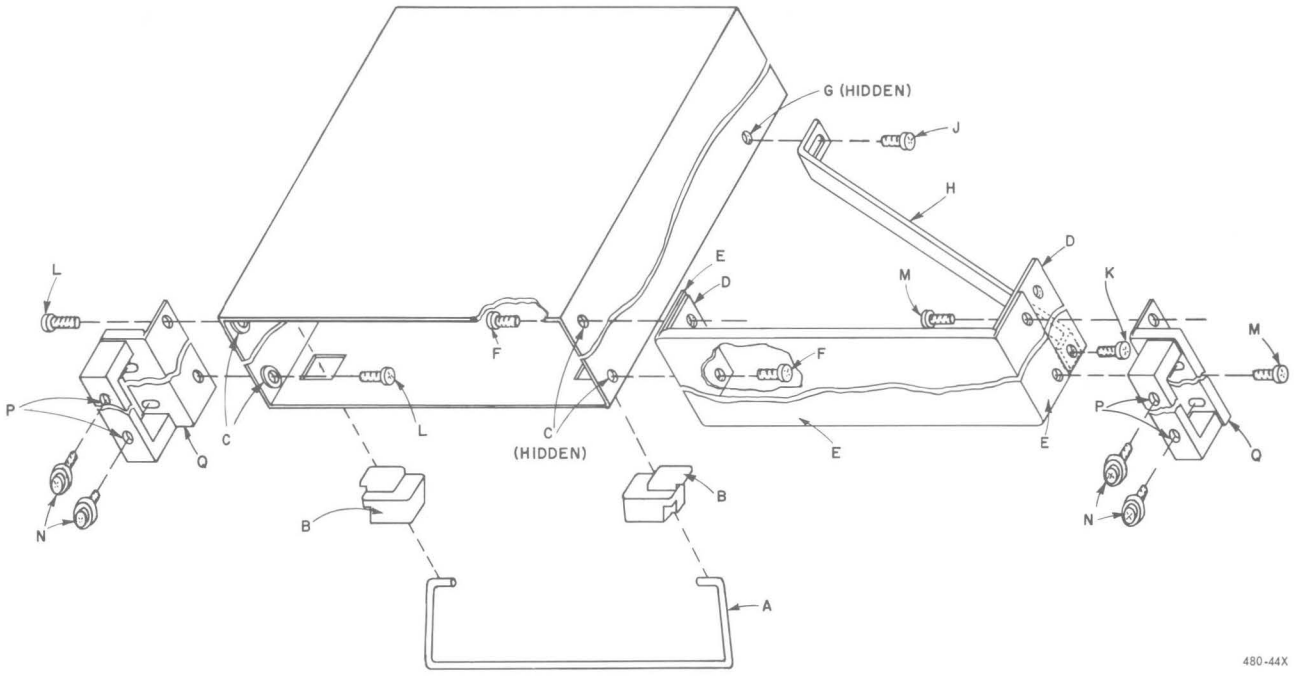


Figure 2-2. Method of mounting the Microvolter and a blank panel in a relay rack.

Operation–Section 3

3.1 GENERAL.

This section contains information on how to: obtain extremely high operational accuracy, if required; how to select the proper mode of operation; the operating procedure for each mode of operation; special operations; and a description of some of the applications in which the 1346 can be used.

3.2 ERRORS AND/OR CORRECTIONS.

The Microvolter does not require the use of calibration charts or correction curves, and its accuracy is more than sufficient for most applications. Where extremely high accuracy is required or where the limits of error must be known, the following information in this paragraph should prove helpful.

3.2.1 Temperature Error.

The 1346 is calibrated for operation at an ambient temperature of 23°C (73°F). For operation in the 1-V ac and 10-V ac modes at other temperatures, see Figure 3-1 for an indication of percent error in the meter reading. Meter readings at ambient temperatures above 73° F have negative percentage errors; readings below 73° F have positive percentage errors.

Avoid large temperature gradients across the instrument to minimize thermal emfs (voltages) on low-level dc outputs. Gold-plated copper binding posts and specially selected materials minimize these emf's under normal operating temperatures.

3.2.2 Harmonic Distortion.

In the 10-V ac mode of operation, the maximum harmonic distortion is less than 0.25% and is dependent on the setting of the LEVEL control, as shown in Figure 3-2 for a 1-kHz signal. If the LEVEL control is set full cw, and the output control of the oscillator is used to adjust the voltage level, the distortion will be less than 0.05%.

In the 1-V ac mode the distortion introduced by the meter circuit is less than 0.01% and is independent of the LEVEL control setting.

3.2.3 Nonsinusoidal Signals.

The instrument's meter is calibrated to read rms for a sinusoidal signal. For all other waveforms the meter will read 1.11 times the rectified average.

3.2.4 Input Impedance Changes.

The 1346's attenuator circuit has constant input impedance only for open-circuit load conditions. Under other than open-circuit conditions, the changing input impedance will be observed on the meter. The meter will deflect up-scale when the FULL SCALE OUTPUT VOLTAGE switch is set from 0 dB to 20 dB. Though both readings are correct, and the correct outputs are obtained for all FULL SCALE OUTPUT VOLTAGE switch positions, it may be desirable to eliminate this deflection. If so, refer to paragraph 5.8.6 for instructions.

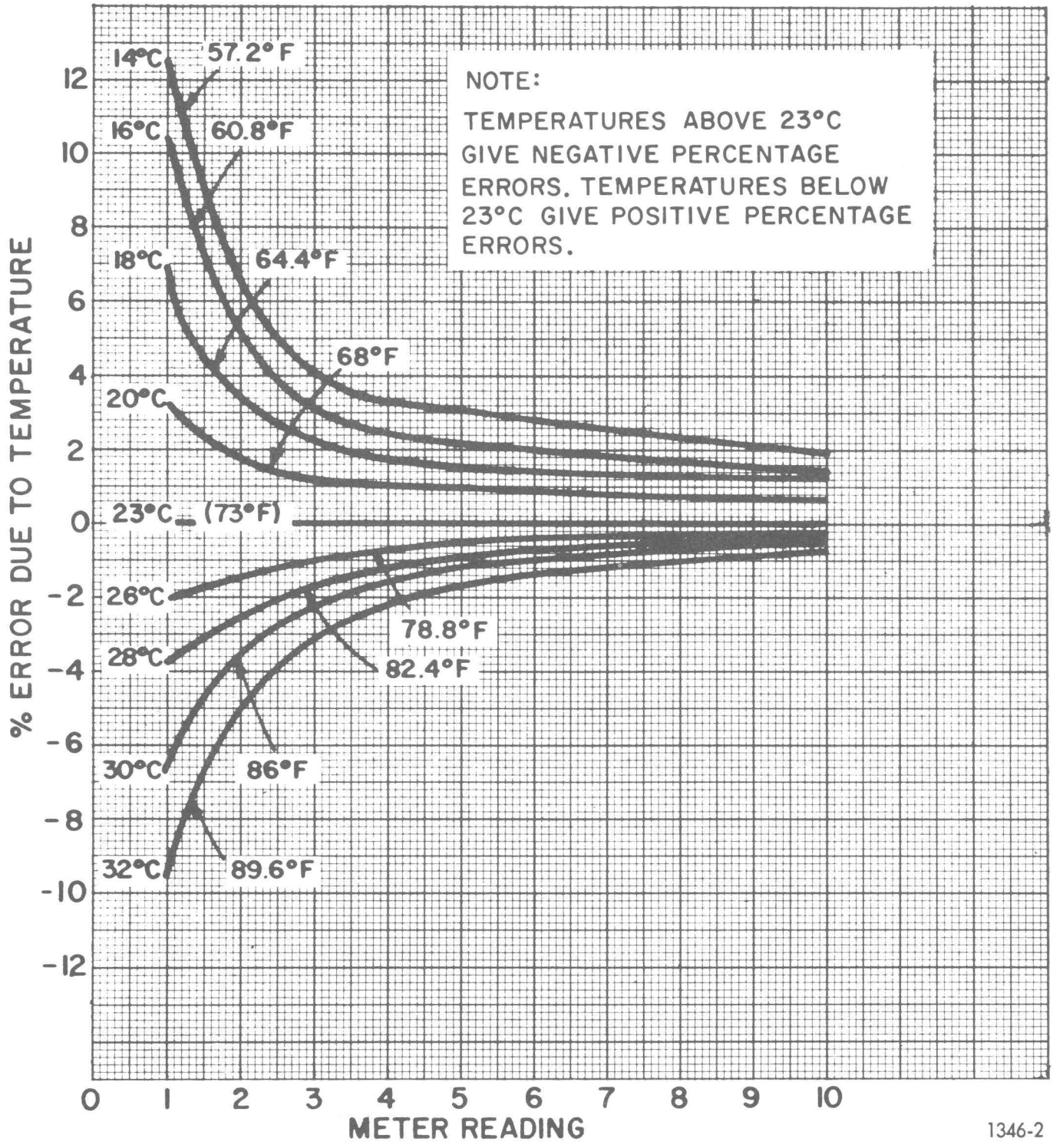


Figure 3-1. Meter reading error introduced for 1-Vac and 10-Vac operation at ambient temperatures other than 23°C (73°F).

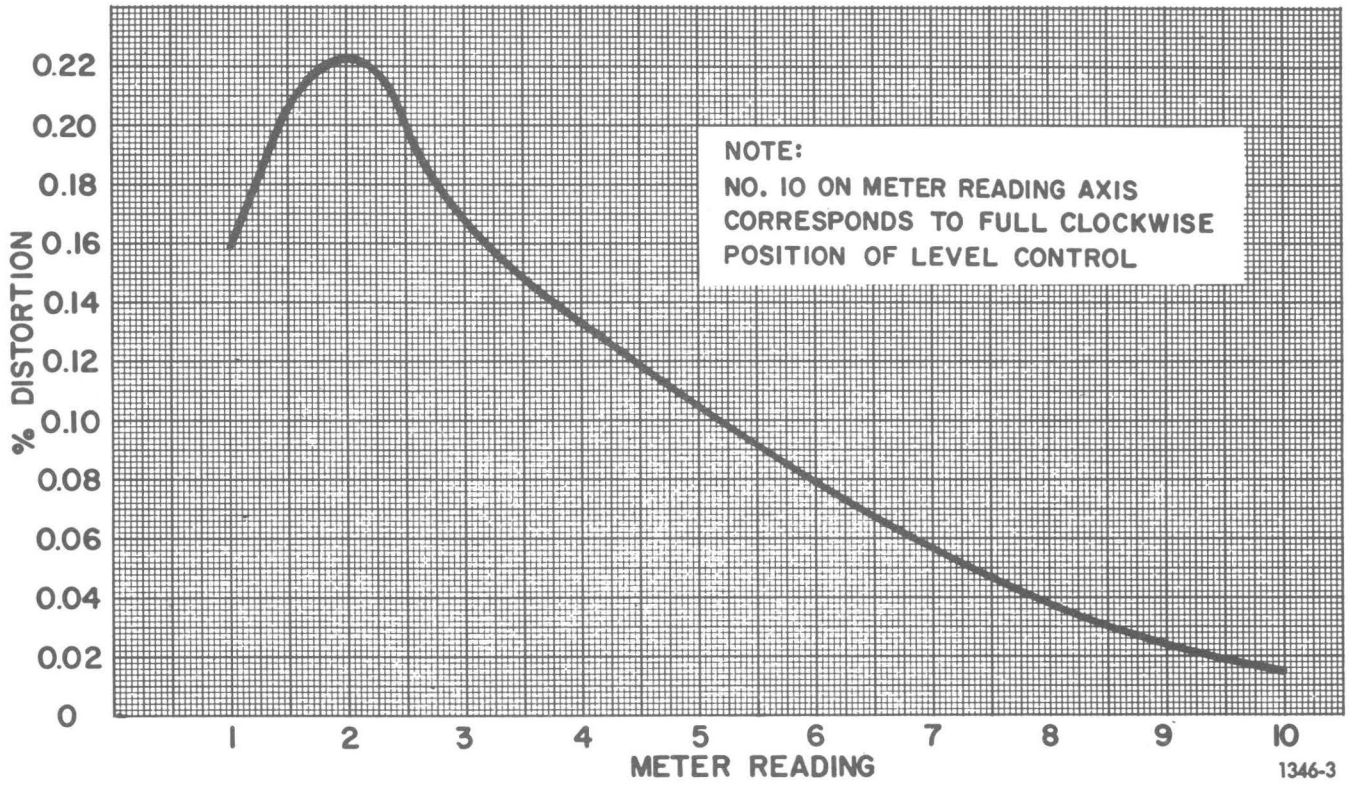


Figure 3-2. Percent harmonic distortion versus LEVEL-control setting for a 1-kHz, 10-V ac input signal.

3.2.5 Output Impedance.

Since the Microvolter indicates open-circuit output voltage, the output impedance (600 Ω) must be taken into account with low-impedance loads. For example, if the output is into a 600-Ω load, the output voltage is actually one-half that indicated on the meter. The actual output can be derived from the equation below, where 600 Ω is the internal output impedance value.

$$E_{OUT\ (Actual)} = E_{METER} \frac{R_{LOAD}}{600 + R_{LOAD}}$$

Figure 3-3 illustrates the output impedance circuit.

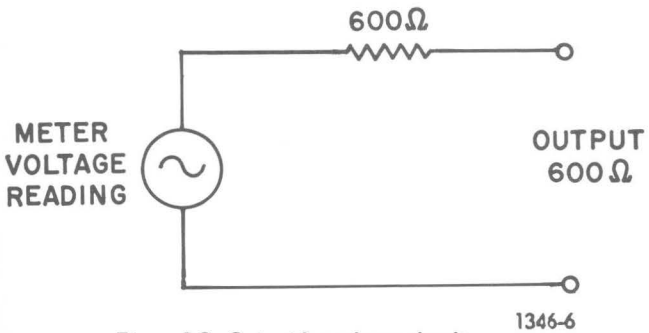


Figure 3-3. Output impedance circuit.

3.3 SELECTION OF OPERATING MODE.

Five modes of operation are provided:

1. +10 V dc
2. -10 V dc
3. 10 V ac
4. 1 V ac
5. Attenuation only.

3.3.1 Plus and Minus 10-V dc Modes.

The ±10-V dc modes provide low-level dc potentials. The 12-V internal battery provides an open-circuit "floatable" output from 1.0 μV to 10 V.

3.3.2 10-V ac Mode.

Use the 10-V ac mode in conjunction with high-output oscillators. An input of at least 10 V into 595 Ω is required. A readily available 20-V open-circuit, 600-Ω oscillator, such as the GR Type 1310, is suitable. Under these conditions the Microvolter will provide an ac output of 1.0 μV to 10 V, introducing less than 0.25% harmonic distortion.

3.3.3 1-V ac Mode.

Use the 1-V ac mode to obtain an ac output from 0.1 μV to 1 V when the source is less than 10 V into 595 Ω, or where harmonic distortion of less than 0.05% in this voltage range is required. The 1-V ac mode requires 1 V into 550 Ω.

3.3.4 Attenuation-Only Mode.

Use the ATTEN-ONLY mode when decade-step attenuation of an externally applied signal is desired or when attenuation of signals that have no meaningful meter reading is desired. In this mode the LEVEL control and meter circuit are disconnected; the output is under control of the FULL SCALE OUTPUT VOLTAGE switch.

3.3.5 Measurements in dBm.

The meter reads dBm for a 600-Ω load and can be read directly when the METER FULL SCALE switch is set to 10 V AC, and the FULL SCALE OUTPUT VOLTAGE switch is set to 0 dB.

If the FULL SCALE OUTPUT VOLTAGE switch is set to another position, subtract the dB reading on the switch dial from the dBm reading on the meter to obtain the output in dBm.

If the input to the 1346 is not adequate for an up-scale reading at a 10-V ac switch setting, set the METER FULL SCALE switch to 1 V ac and the FULL SCALE OUTPUT VOLTAGE switch to 0 dB. Subtract 20 dB from the meter reading to obtain the correct output reading under this condition. If the FULL SCALE OUTPUT VOLTAGE switch is set to a position other than 0 dB, subtract 20 dB and the dB reading on the switch from the meter reading to determine the correct output in dBm.

The dBm scale accuracy is ± 5% of the reading.

3.4 OPERATING PROCEDURE.

3.4.1 Plus and Minus 10-V dc Modes.

To provide outputs from 1 μV to 10 V dc, perform the following steps:

a. Set the 1346's switches and controls to the following positions:

LEVEL . . . . . .Full ccw
METER FULL SCALE . . . . . +10 V DC or -10 V DC
FULL SCALE OUTPUT VOLTAGE . Desired attenuation
OUTPUT ON-OFF . . . . . .ON

b. Turn the LEVEL control clockwise to increase the meter reading. The open-circuit output voltage is that indicated on the meter DC scale, and the meter full-scale range is indicated in green on the FULL SCALE OUTPUT VOLTAGE switch dial. For example, if the meter reads 5, and the switch dial shows 100 mV in green, the open-circuit output voltage is 50 mV.

NOTE

The mark on the down-scale side of 1 on the meter's DC scale represents 0.8.

The internal battery can be removed and an external dc source substituted by connecting the source to the INPUT terminals. A 12-V dc source is recommended.

CAUTION

Do not apply more than 12 V to the instrument.

3.4.2 10-V ac Mode.

To provide ac outputs from 1 μV to 10 V ac, perform the following steps:

a. Before connecting an oscillator to the 1346, set the 1346's controls and switches to the following positions:

METER FULL SCALE . . . . . 10 V AC
LEVEL . . . . . .Full ccw
FULL SCALE OUTPUT VOLTAGE . Desired attenuation
OUTPUT ON-OFF . . . . . .ON

b. Connect an oscillator with an output of at least 10 V rms into 595 Ω to the INPUT terminals. To obtain good meter resolution and low harmonic distortion (refer to paragraph 3.2.2), do not exceed an input of 10 V rms.

c. Adjust the LEVEL control to obtain the desired meter reading. The open-circuit output voltage is indicated on the meter's AC scale. The full-scale range is indicated in green on the FULL SCALE OUTPUT VOLTAGE switch dial. For example, if the meter reads 5, and the switch dial shows 100 mV, the open-circuit voltage is 50 mV.

3.4.3 1-V ac Mode.

To obtain ac outputs from 0.1 μV ac to 1 V ac, perform the following steps:

NOTE

Make sure the meter reads full scale when the instrument is set to the ± 10-V dc modes. This insures that the internal battery's strength is adequate for providing power to the 1-V ac meter circuit.

a. Before connecting the oscillator to the 1346, set the 1346's switches and controls to the following positions:

METER FULL SCALE . . . . . 1 V AC
LEVEL . . . . . .Full ccw
FULL SCALE OUTPUT VOLTAGE . Desired attenuation
OUTPUT ON-OFF . . . . . .ON

NOTE

When the instrument is switched to the 1-V ac mode, the meter's pointer will swing up-scale and then return gradually to zero.

b. Connect an oscillator with an output of at least 1-V rms into 550 Ω. (A GR Type 1309 Oscillator is recommended.) To obtain good meter resolution and low harmonic distortion, do not exceed an input of 1-V rms.

c. Adjust the LEVEL control to obtain the desired meter reading. The open-circuit output voltage is indicated on the meter's AC scale. The full-scale range is indicated in green on the FULL SCALE OUTPUT VOLTAGE switch dial.

3.4.4 Attenuation-Only Mode.

To obtain decade attenuation, set the 1346's switches to the following positions (the LEVEL control has no effect in this mode):

METER FULL SCALE . . . . .ATTEN ONLY
FULL SCALE OUTPUT VOLTAGE . Desired attenuation
OUTPUT ON-OFF . . . . . .ON

CAUTION

Make sure the input does not exceed 10 V rms.

3.5 TURN-OFF.

To turn-off the instrument:

a. Set the OUTPUT switch to OFF.

b. Set the METER FULL SCALE switch to either 10 V AC or ATTEN ONLY. This removes the internal battery from operation.

NOTE

A red indication on the FULL SCALE OUTPUT VOLTAGE switch dial indicates the battery is in use.

c. If the instrument is to be stored for a long time, remove the battery.

3.6 SPECIAL OPERATIONS.

3.6.1 Operation with a Nonsinusoidal Input.

To provide an output with up to 140-dB attenuation of a nonsinusoidal input, use the procedures in paragraphs 3.4.2 and 3.4.3. The meter will, however, read 1.11 times the full-wave rectified average.

CAUTION

Make sure that the input does not exceed 10 V rms.

3.6.2 Superimposed Waveform on the Dc.

A waveform can be superimposed on the dc by introducing an ac-coupled signal at the input terminals when the instrument is operating in the plus and minus 10-V dc modes. Use the procedure in paragraph 3.4.1, applying the ac signal to the input terminals.

An alternate method is to remove the battery and introduce either a separate dc signal at the input terminals or a composite ac-dc signal. As in the above procedure, the level meter will read the dc level.

3.7 APPLICATIONS.

3.7.1 General.

The Microvolter is a metered, calibrated attenuator that can be used as a self-contained low-level dc source and, in conjunction with an appropriate oscillator, as a source of from 0.1 μV to 10 V of any ac waveform with a spectrum up to 100 kHz. The instrument converts almost any sine- or square-wave, noise, tone-burst, or other generator for operation as a calibrated-output source.

Use of the Microvolter converts an oscillator into a standard-signal generator, valuable in such measurements as gain or loss, frequency response characteristics, overload level, and hum level on amplifiers, networks, and other audio-frequency equipment. The combination of oscillator and Microvolter is also useful in the measurement of the generated voltage of microphones, vibration and phonograph pickups, and other transducers by the insert-voltage method.

3.7.2 Low-Level Ac Source.

Since the 1346 gives a low distortion output from 0.1 μV to 10 V with a 600-Ω output impedance, the instrument is particularly useful in gain and distortion measurements of high-and low-gain amplifiers. The instrument is also useful in determining the input levels that cause nonlinearities, such as clipping and saturation.

3.7.3 Low-Level Dc Source.

The on-off switching feature makes the 1346 valuable in gain measurements of dc amplifiers. The ability to superimpose an ac signal on a dc level makes it easy to determine the linear region and saturation levels.

The dc source is also useful in determining the switching levels of digital circuits.

3.7.4 Low-Level Nonsonusoidal Source.

The 1346 can be used as an attenuator with any type of audio waveform; therefore, with random noise, the instrument can be used to determine signal-to-noise ratios. Numerous other applications, such as acoustic measurements, are possible using a nonsinusoidal input.

3.7.5 Use with a Tone-Burst Generator.

The 1346 can be used as an attenuator with the GR Type 1396 Tone-Burst Generator, therefore making it useful in such applications as meter ballistics, transducer calibration and testing, music-power tests, radar-type applications, amplitude transient testing, under-water sound applications, filter testing, low-speed digital testing, and many other applications.

Theory–Section 4

4.1 GENERAL.

The Type 1346 consists of four basic circuits:

1. Internal 12-V battery
2. Continuously adjustable level control
3. Meter circuit
4. 20-dB-per-step output attenuator (120 dB output attenuator).

Figure 4-1 shows a block diagram of the 1346. The instrument operates in five modes of operation: -10 V dc, +10 V dc, 1 V ac, 10 V ac and attenuation-only, determined by the setting of the front-panel METER FULL SCALE switch. In the ac modes of operation, the instrument uses an external ac source. In the dc modes the instrument can use an external dc source or its own 12-V internal battery source.

The external voltages, if used, are introduced at the INPUT terminals and applied to the continuously adjustable level control (potentiometer), provided the instrument is not in the attenuation-only mode of operation, in which case the level control is bypassed. If the internal battery source is used, the dc voltage is also applied to the level control.

The level control, which has a range of 20 dB, is adjusted by the front-panel LEVEL control. The resultant voltage is applied to the 120-dB output attenuator and to the meter, which measures the input to the attenuator. Therefore, in the ac and dc modes, meter deflection is controlled by the LEVEL control.

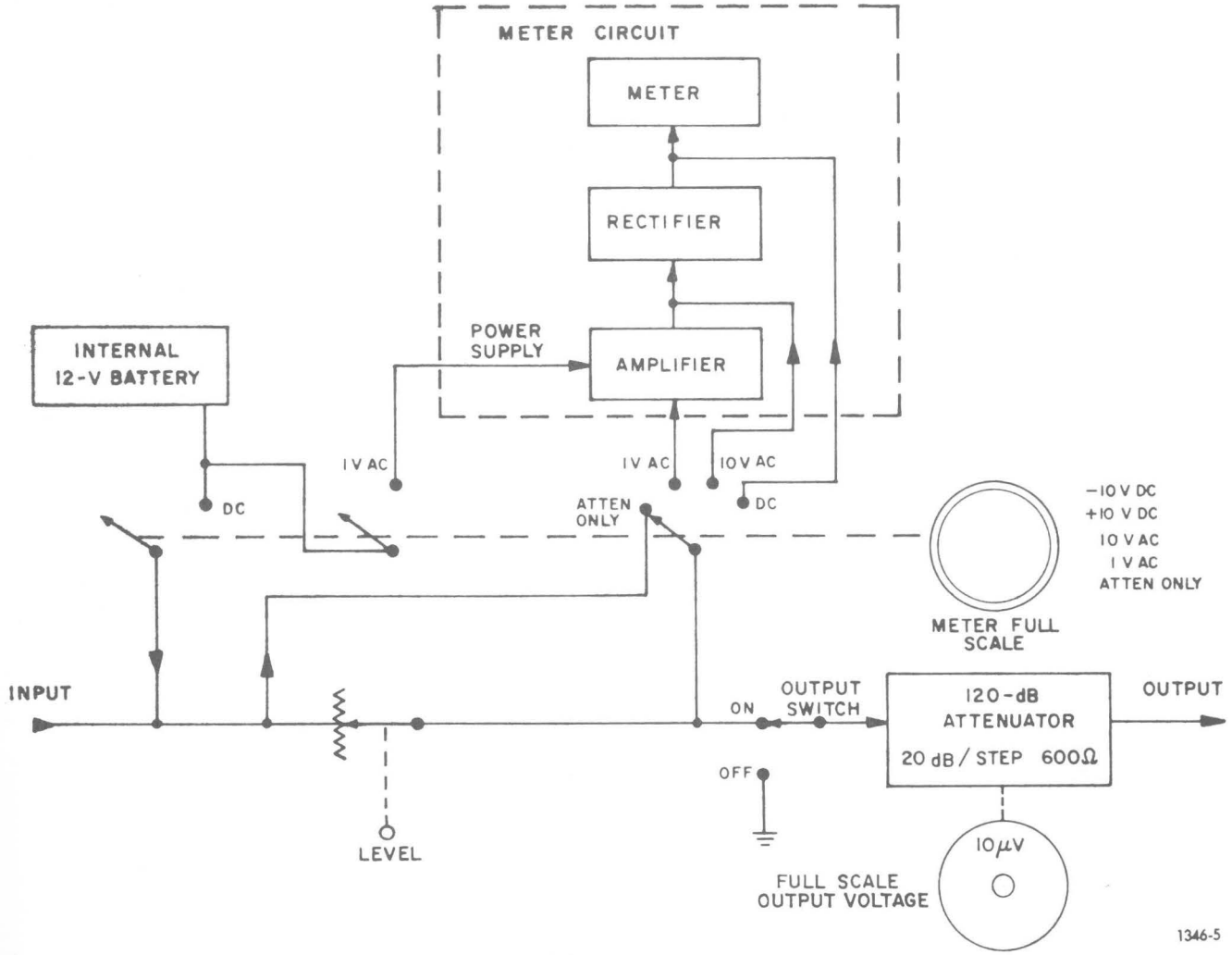


Figure 4-1. Block diagram of the Type 1346 Audio-Frequency Microvolter.

The 120-dB-output attenuator provides attenuation from 0 to -120 dB in 20-dB steps, behind 600 Ω output impedance and is controlled by the FULL SCALE OUTPUT VOLTAGE switch. The switch selects the amount of attenuation desired and indicates in green on the switch dial the meter range. For example, if the meter reads 5, and the switch dial shows 10 μV in green, the meter reading is 5 μV, open-circuit voltage.

The meter is calibrated in dc and rms volts and in dBm, and is average-responding in ac operation. The open-circuit output voltage in all modes of operation, including attenuation-only is, therefore, the voltage at the input to the 120-dB output attenuator, reduced by the amount of dB selected.

In the attenuation-only mode the input is connected directly to the 120-dB output attenuator, bypassing the level control and meter circuit. This mode provides decade attenuation only.

In the 1-V ac mode the internal battery source supplies a bias voltage to the amplifier in 1-V ac portion of the meter circuit.

The front-panel OUTPUT ON-OFF switch reduces the output to zero when set to OFF, maintaining an output impedance of 600 Ω.

4.2 CIRCUIT DESCRIPTION.

Figure 6-3 shows a detailed drawing of the switch circuitry and Figure 6-5 shows the schematic of the Microvolter. Refer to these figures for the following discussion.

4.2.1 Internal Battery.

The internal battery is a 12-V dry-cell and is used in the ±10-V dc and 1-V ac modes of operation. In the ±10-V dc modes it supplies dc voltage, and in the 1-V ac mode, it biases the transistor amplifier in the 1-V ac portion of the meter circuit. In the 10-V ac and attenuation-only modes the battery can be removed without affecting instrument operation in these modes. In dc operation the battery can be removed, if desired, and replaced by an external dc source.

4.2.2 Level Control.

The continuously adjustable level control is a 25-kΩ potentiometer controlled by the LEVEL control. The level control selects a portion of the input to be presented at the input to the 120-dB output attenuator and the meter. Input impedance varies with the setting of the LEVEL control, 120-dB output attenuator, and load, but can be adjusted to remain constant when varying the 120-dB output attenuator for load impedances greater than or equal to 50 Ω.

4.2.3 Meter Circuit.

The meter measures the voltage at the input to the 120-dB output attenuator. The meter has three circuits for this function; one for dc measurements (±10 V dc) and two for ac measurements (1 V ac and 10 V ac). The appropriate circuit is selected by the METER FULL SCALE switch.

The dc dircuit is comprised of a potentiometer (R210) in series with the meter movement. The potentiometer provides for calibration (DC CAL) of the meter DC scale.

The ac portion is comprised of two circuits; the 1-V ac and 10-V ac circuits. Both of these circuits feed a full-wave bridge rectifier, which provides a rectified-average current to the meter.

The 10-V ac circuit is comprised of a voltage divider consisting of resistors R201 and R203 and potentiometer R202 (10 V AC CAL) and adjustable capacitor C201. Potentiometer R202 provides for calibration of the meter 10-V AC scale, and adjustable capacitor C201, a frequency-compensation adjustment, provides for calibrating the meter 10 V AC scale with a 100-kHz signal.

The 1-V ac circuit consists of a single-stage transistor amplifier in series with the bridge rectifier and meter movement. Calibration of the 1-V AC meter range is provided by potentiometer R208 (1 V AC CAL), which can vary the transistor's emitter resistance. The transistor is biased by the internal 12-V battery when the METER FULL SCALE switch is set to 1 V AC.

The meter has a logarithmic meter movement and is calibrated for ac, dc, and dBm. For both ac modes the meter reads rms for a sinusoidal signal.

Diode CR101 provides protection for the meter against overloading.

4.2.4 Output Attenuator.

The 120-dB output attenuator is a modified ladder network that maintains a constant 600-Ω impedance between the point where the voltage is measured by the meter and the output. Thus, the output impedance for the voltage read on the meter is, effectively, 600 Ω. Output attenuation is in 20-dB steps from 0 to -120 dB, selected by the FULL SCALE OUTPUT VOLTAGE SWITCH.

Service and Maintenance—Section 5

5.1 GR FIELD SERVICE.

Our two-year warranty attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see last page), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

5.2 INSTRUMENT RETURN.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest District Office, requesting a "Returned Material Tag." Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid necessary delay.

5.3 MINIMUM PERFORMANCE STANDARDS.

5.3.1 General.

The following paragraphs contain information to determine rapidly that the Microvolter is performing within specifications. The procedures enable instrument-standards laboratories and equivalently equipped service facilities to perform routine calibration checks on properly functioning instruments and to determine that a repaired instrument has been restored to proper operation. These procedures are bench checks that require the use of only front-panel controls and externally available test points (i.e., instrument disassembly is neither required nor recommended).

Table 5-1 lists recommended test equipment for a minimum performance check and adjustments.

The minimum performance standards include the following checks:

1. Calibration checks
   a. ±10 V dc
   b. 10 V ac
   c. 1 V ac
2. Attenuation check.

If the instrument is out of calibration and adjustment as determined by calibration checks, refer to paragraph 5.8 for instructions for the calibration and adjustment of the instrument.

Table 5-1

TEST EQUIPMENT

Type	Requirement	Recommended*
Oscillator	100-kHz, 10-V rms behind 600 Ω output.	GR Type 1310.
Voltmeter	0.5% ac dc accuracy and high input impedance.	GR Type 1820 with P1 or P2 plug-in (P2 preferable).
Precision Decade Transformer or Attenuator	Decade Transformer: 7 step decades; accuracy 5 ppm at 1 kHz. (Attenuator: 120-dB attenuation in 20-dB steps; accuracy 0.05% at 1 kHz.	Decade Transformer, GR Type 1493.
Tuned Amplifier and Null Detector	1-kHz operation, low noise level (0.03 μV, input short circuited), 1 μV sensitivity.	GR Type 1232.

*Or equivalent

5.3.2 General Instructions.

Perform all checks in an ambient temperature of 23°C and allow sufficient time for the test instruments to warm-up. Allow the 1346 to stabilize at this temperature for at least one hour, before performing checks. Also check that a full-strength 12-V battery is installed in the 1346. Refer to paragraph 5.5 for cabinet removal instructions.

5.3.3 10-V dc Check.

a. Connect a digital voltmeter (GR Type 1820 or equivalent), or a voltmeter with at least 0.5% ac-dc accuracy, to the 600 Ω OUTPUT terminals.

b. Set the 1820 voltmeter, if used, to DC VOLTS AUTO RANGE and the 1346's controls to the following positions:

METER FULL SCALE . . . . . +10 V dc
METER FULL SCALE
OUTPUT VOLTAGE . . . . . .10 V
OUTPUT ON-OFF . . . . . .ON

c. Adjust the LEVEL control for 1346 meter readings of 10, 7, and 1 V dc and observe that the voltmeter readings are within ±3%.

5.3.4 10-V ac Check.

a. Set the 1346's controls as follows:

b. Connect an oscillator (GR Type 1310 or equivalent) to the INPUT terminals and apply a 1-kHz, 10 V rms (approximately) input signal to the 1346.

METER FULL SCALE . . . . . 10 V ac
METER FULL SCALE
OUTPUT VOLTAGE . . . . . .10 V
LEVEL . . . . . Full cw
OUTPUT ON-OFF . . . . . .ON

c. Adjust the LEVEL control for 1346 meter readings of 10, 5, and 1.7 V ac and observe that the voltmeter readings are within ±4%. Adjust the oscillator if necessary for a full-scale meter reading.

d. Change the oscillator frequency to 100 kHz, make the same readings as in step c and observe the voltmeter reads the corresponding voltages, ±4%.

5.3.5 1-V ac Check.

a. Use the same connections and control settings as in paragraph 5.3.4. However, apply a 1 kHz, 1 V rms (approximately) to the INPUT terminals and set the METER FULL SCALE switch to 1 V ac. Adjust the oscillator if necessary for a full-scale reading.

b. Adjust the LEVEL control for 1346 meter readings of 10, 5, and 1.7 V ac and observe that the voltmeter readings are within ±4%.

5.3.6 Attenuation.

a. Establish the test setup shown in Figure 5-1, leaving the voltmeter "floating" in the setup. If the 1820 Voltmeter is used, turn the 3-wire power cord plug so that the ground prong is not inserted into the plug, or connect a suitable adaptor to the line-voltage source jack to disconnect the ground. Use shielded patch cords and adaptors for all connections. Refer to Table 1-3 for available GR patch cords and adaptors. An attenuator can be used in place of the Precision Decade Transformer; refer to Table 5-1 for details.

b. Set the switches and controls on the instruments to the following positions:

1. Precision Decade Transformer:
   Decade 10^{-7} X
   All other decades 9
   CONTINUOUS DECADE . . . . . .OUT
   All ground straps connected.

2. Type 1346:
   METER FULL SCALE . . . . . .ATTEN ONLY
   FULL SCALE OUTPUT VOLTAGE 10μV

3. Tuned Amplifier and Null Detector:
   GAIN . . . . . .OFF

CAUTION

Do not apply more than 15 V to the 1346 in this test.

c. Turn on the above listed instruments and the Type 1310 Oscillator, applying a 1-kHz, 15.0 ±0.01-V signal (under load) to the Precision Decade Transformer. Use the Digital Voltmeter to measure the oscillator's output. The 15-V output insures a minimum amount of noise in the 1232.

d. Connect the voltmeter to the Tuned Amplifier and Null Detector and set the voltmeter's controls as follows:

MEASUREMENT . . . . . .ON
INPUT FILTER . . . . . MAX
FUNCTION . . . . . .LOG
RANGE . . . . . .AUTO
POWER . . . . . .ON

e. Set the 1232 amplifier's controls as follows:

FILTER TUNING &
FILTER FREQUENCY . . . . . 1 kHz
METER . . . . . -20dB

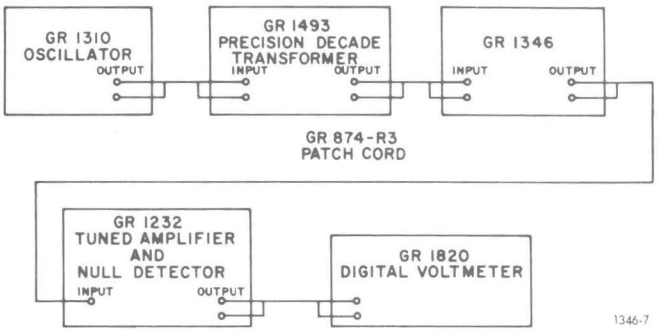


Figure 5-1. Attenuation test set-up.

f. Turn on the amplifier and tune for a maximum reading; adjust the GAIN control for a meter reading of approximately 78. If another amplifier is used in place of the 1232, select the gain with the lowest noise level but with an adequate output for the voltmeter.

g. After insuring that the instruments are warmed-up sufficiently, note the reading on the voltmeter.

h. Set the decade transformer's 10^{-1} decade switch to 0. Disconnect the voltmeter and recheck the output of the oscillator; readjust the oscillator for a 15.0, ±0.01-V output.

i. Reconnect the voltmeter, set the 1346's FULL SCALE OUTPUT VOLTAGE switch to 100 μV and note that the voltmeter reading is within ±0.04 dB of the previous reading.

j. Step down the decade transformers decade switches to 0, one at a time, setting the 1346's FULL SCALE OUTPUT VOLTAGE switch to the position noted in Table 5-2 for each decade switch position. Observe the voltmeter reading for each switch position is within ±0.04 dB of the previous reading (not the first reading of the test). Recheck and adjust the oscillator's output again after changing the position of the 10^{-2} decade switch. It is not necessary to recheck and adjust the oscillator's output after changing the positions of the remaining decade switches. Table 5-2 lists the sequence of switch settings for the decade transformer and 1346 and the acceptable change in dB between each reading for each step in the sequence.

5.4 COMPONENT LOCATIONS.

Most of the circuits for the instrument are one etched-circuit board assembly, occupying the center position in the instrument. Figure 5-2 shows the locations of internal adjustments, components and test points. Figures 5-2 and 6-1 identify the locations of components on the circuit board and panels.

5.5 CHASSIS REMOVAL AND REPLACEMENT.

To gain access to the components, battery connections, and internal adjustments, loosen the two captive screws on the rear panel and carefully slide the chassis out of the cabinet. To replace the chassis, reverse the removal procedure.

5.6 ETCHED-CIRCUIT BOARD.

The etched-circuit board has components on one side and the circuitry on the opposite side. A layer of metal plated through the component connection holes provides the electrical connection to the circuitry.

When removing or replacing components, use a low-heat soldering iron and a small-diameter rosin-core solder. Do not subject the components or boards to excessive or prolonged heat. Components can be removed by placing the soldering iron on the component lead on either side of the board and pulling up on the lead. If a component is obviously faulty or damaged, clip the leads close to the component and then remove the leads.

The component lead hole should be cleaned before inserting a new lead. Heat the solder in the hole, quickly remove the soldering iron, and insert a pointed nonmetalic object, such as a tooth pick.

Shape the new component leads, insert them into the holes, reheat with the iron, and add solder as necessary to form a good electrical connection. Clean any excess flux from the connection and adjoining area.

Table 5-2
ATTENUATION-CHECK SEQUENCE

Step	Type 1493 Decade Switch Positions							1346 Switch Position	Acceptable Change Between Voltmeter Readings (dB)
	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}		
1	9	9	9	9	9	9	X	10 μV	
2	0	9	9	9	9	9	X	100 μV	± 0.04
3	0	0	9	9	9	9	X	1mV	± 0.04
4	0	0	0	9	9	9	X	10mV	± 0.04
5	0	0	0	0	9	9	X	100mV	± 0.04
6	0	0	0	0	0	9	X	1V	± 0.04
7	0	0	0	0	0	0	X	10V*	-0.03, ± 0.04

*Subtract -0.03 dB from previous 1-V reference reading because input impedance of the 1346 changes at this step.

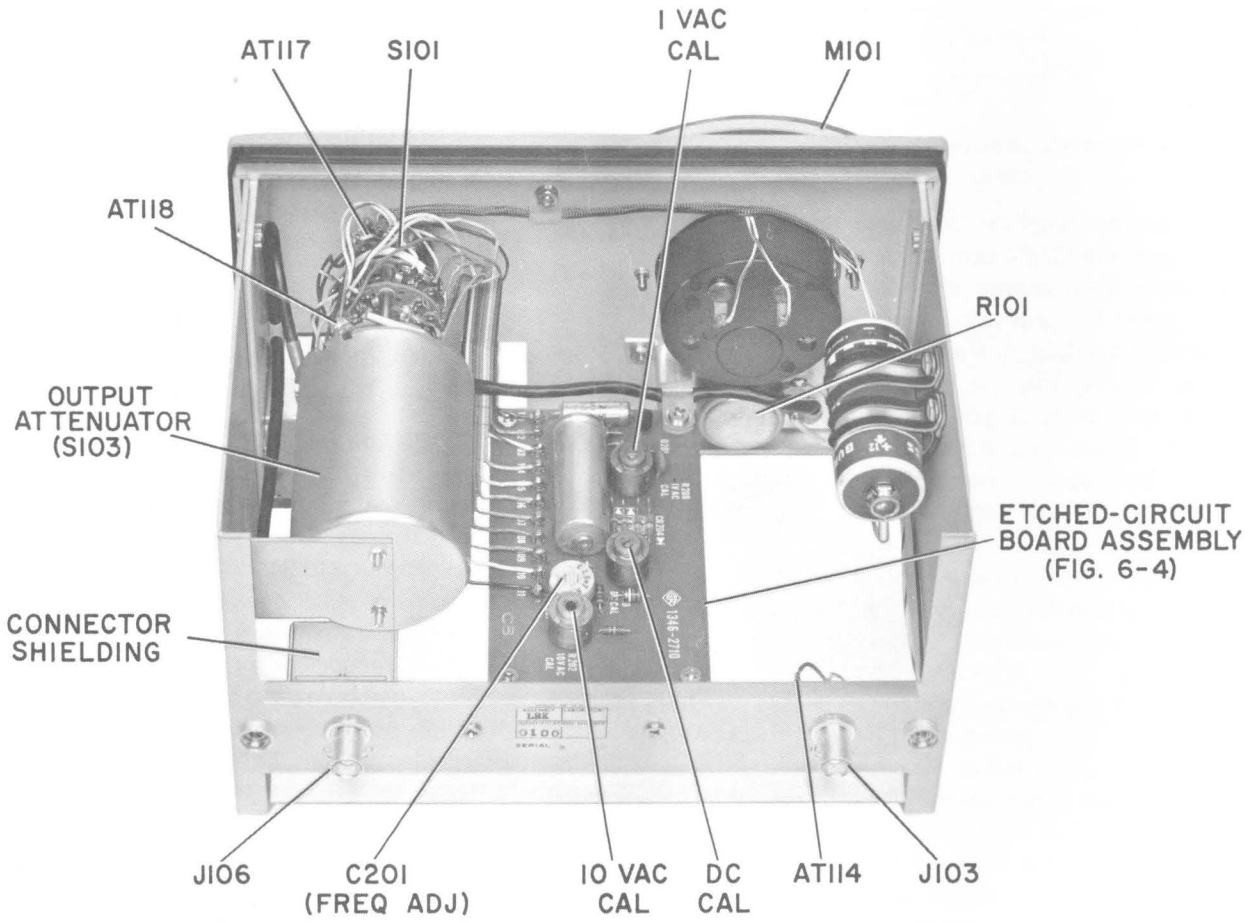


Figure 5-2. Interior view of the Type 1346 Audio-Frequency Microvolter.

5.7 TEST POINTS.

Signal measurements can be made at anchor terminals (AT's) on the circuit board and front and rear panels. The terminals are identified on the schematics in Section 6. The circuit board AT's are clearly labeled on the component-side of the board; however, the AT numbers (101–111) on the board are not prefixed by letters.

The front- and rear-panel INPUT and OUTPUT 600 Ω connectors each have an AT on the rear side. These AT's are not identified by legends. The OUTPUT ON-OFF switch has one AT on the bottom right side (AT116). Other AT's are identified in Figure 5-2.

5.8 CALIBRATION AND ADJUSTMENTS.

5.8.1 General.

Perform the following procedures, as applicable, when it has been established that the Microvolter is out of adjustment or calibration as determined during operation, by performance checks, or after corrective maintenance has been performed. Table 5-1 lists the test equipment required to perform the procedures. The adjustments are on the etched-circuit board assembly in the instrument and are clearly marked. To gain access to the adjustments, remove the chassis from the cabinet, as described in paragraph 5.5. Perform the adjustments at an ambient temperature of 23°C and allow the 1346 to stabilize at this temperature for at least one hour.

NOTE

Before performing the following adjustments, it is recommended that the attenuation check in paragraph 5.3.6 be performed to insure that the 1346's meter is reading the correct voltage at the output terminals.

5.8.2 10-V dc Adjustment.

NOTE

Make sure a full-strength 12-V battery is installed in the instrument before performing this adjustment.

a. Set the switches and controls to the following positions:

METER FULL SCALE . . . . . +10 V dc
FULL SCALE OUTPUT VOLTAGE . . .10 V
OUTPUT ON-OFF . . . . . .ON

b. Connect the voltmeter to the OUTPUT 600 Ω terminals and adjust the LEVEL control for 10-V dc reading on the voltmeter.

c. Adjust R210 for a full-scale 1346 meter reading of 10 V dc on the lower scale.

NOTE

Adjustment of R210 may change the voltmeter reading. Check that the voltmeter still reads 10 V dc; adjust the 1346's LEVEL control if necessary.

d. Set the METER FULL SCALE switch to -10 V dc and check that voltmeter reading is -10 V dc, ±0.1 V.

e. Set the METER FULL SCALE switch to +10 V dc and adjust the LEVEL control to obtain 1346 meter readings of 10, 7, and 1. Check that the voltmeter reads within ±3% of the values indicated on the 1346's meter. Readjust R210, if necessary, to obtain the correct readings.

5.8.3 10-V ac Adjustment.

a. Set the switches and controls to the following positions:

METER FULL SCALE . . . . . 10 V ac
FULL SCALE OUTPUT VOLTAGE . . .10 V
LEVEL CONTROL . . . . . Full cw
OUTPUT ON-OFF . . . . . .ON

b. Apply a 1-kHz, 10-V rms signal to the input terminals.

c. Connect the voltmeter to the OUTPUT 600 Ω terminals and adjust the oscillator output so that the voltmeter reads slightly greater than 10 V ac.

d. With the LEVEL control, fine adjust the voltmeter reading for a reading of 10 V ac, ±0.1 V.

e. Adjust R202 for a 1346 meter reading of 10 V ac on the upper scale. Check that the voltmeter still reads 10 V ac, ±0.1 V; adjust the LEVEL control, if necessary, and R202 for a 1346 meter reading of 10 V ac.

f. Adjust the LEVEL control to obtain meter readings of 10, 5, and 1.7. Check that the voltmeter reads within ±4% of the values indicated on the meter. Readjust R202, if necessary, to obtain the correct readings.

5.8.4 Frequency Adjustment.

a. Set the 1346's controls to the positions described in paragraph 5.8.3, connect the voltmeter to the OUTPUT 600 Ω terminals, and apply a 100-kHz signal to the INPUT terminals so that the voltmeter reads slightly greater than 10 V.

NOTE

Make sure the 1346's LEVEL control is maintained full cw.

b.Adjust C201 for a 10 V ac or minimum reading on the 1346's meter.

c. Adjust the LEVEL control to obtain meter readings of 10, 5, and 1.7 V ac. Check that the voltmeter reads within ±4 % of the values indicated on the meter. Readjust C201, if necessary, to obtain correct readings. If more than one-quarter turn of C201 is required, repeat the procedure in paragraph 5.8.3, adjusting R202 for readings with less tolerance, but remaining within the ±4 % limits.

5.8.5 1-V ac Adjustment.

a. Set the switches and controls to the following positions:

METER FULL SCALE . . . . . .1 V ac
FULL SCALE OUTPUT VOLTAGE . . .10 V
LEVEL . . . . . Full cw
OUTPUT ON-OFF . . . . . .ON

b. Connect the voltmeter to the OUTPUT 600 Ω terminals and apply a 1-kHz, 1-V rms (approximately) signal to the INPUT terminals.

c. Adjust the oscillator output so that the voltmeter reads slightly greater than 1 V ac ±0.01 V.

d. Adjust R208 so that the 1346's meter reads 10 V on the upper scale.

e. Using the 1346's LEVEL control,set the 1346's meter to read 10, 5, and 1.7; and observe that the voltmeter reads the corresponding voltages (based on a 1-V ac full scale reading), ±4 %. If any readings are not correct, readjust R208 until all readings are within tolerance.

5.8.6 Input Impedance Changes.

The 1346's attenuator circuit has constant input impedance only for open-circuit load conditions. Under other than open-circuit conditions, the changing input impedance will be observed on the meter. The meter will deflect up-scale when the FULL SCALE OUTPUT VOLTAGE switch is set from 0 dB to 20 dB. Though both readings are correct, and the correct outputs are obtained for all FULL

SCALE OUTPUT VOLTAGE switch positions, it may be desirable to eliminate this deflection. This can be accomplished for any load impedance by placing an appropriate resistor (or a potentiometer, if desired) across contacts 111R and 107R of OUTPUT switch S102.

Selection of the proper resistor is determined by the equation below. Table 5-3 lists resistor values (R_x) for various load conditions (R_L)

$$R_x = \frac{44.4 \times 10^3 R_L^2 + 53.3 \times 10^6 R_L + 16.0 \times 10^9}{0.018 R_L^2 + 44.0 \times 10^3 R_L + 26.4 \times 10^6}$$

Table 5-3

RESISTOR VALUES FOR VARIOUS LOAD CONDITIONS

R_x (Ω)	R_L (Ω)
656	50
1220	600
5630	5000

If a potentiometer is used, it can be connected across the switch contacts and adjusted to obtain the correct value, eliminating the need to calculate the resistor value.

5.9 TROUBLE ANALYSIS.

5.9.1 General.

Table 5-4 lists the recommended test equipment to perform complete maintenance of the instrument. There are no preventive maintenance procedures.

CAUTION

It is recommended that the battery be removed if the instrument is stored for a long time.

Table 5-5 lists the fault symptoms and the probable causes. The instrument should be inspected for broken and shorted wiring and damaged or faulty components before attempting to troubleshoot.

Use the panel controls whenever possible to determine the exact mode or portion of a mode that has failed. For example, the METER FULL SCALE switch can be used to isolate a fault to either the 1-V ac, 10-V ac, bridge rectifier, 10-V dc, and meter-movement circuits, or to the level-control circuit or 120-dB output attenuator by observing the meter reading and output for the various modes of operation.

Section 6 contains the schematics, etched-board layout, and replaceable parts lists for troubleshooting and repair.

Table 5-4

TEST EQUIPMENT FOR TROUBLESHOOTING

Instrument	Requirements	Recommended*
Volt-Ohm-Milliammeter	- - -	Triplett Type 630-NA.
Oscilloscope	100kHz bandwidth.	Tektronix Type 531A with suitable plug-in.
Oscillator	10-V rms, 600-Ω, output; frequency to 10 kHz.	GR Type 1310.

*Or equivalent

5.10 REPLACEMENT OF CONTROLS.

5.10.1 Full Scale Switches.

a. Set the METER FULL SCALE SWITCH to ATTEN ONLY and the FULL SCALE OUTPUT VOLTAGE switch to 0 dB.

b. Hold the chassis securely and pull the control knob with the fingers.

CAUTION

Do not use a screwdriver or other instrument to pry off the knob if it is tight, since this might mar or crack the dial. Do not lose the retention spring in the knob when it is removed.

c. Remove the setscrew from the bushing; use a hex-socket key wrench.

d. Remove the bushing and FULL SCALE OUTPUT VOLTAGE dial.

NOTE

To separate the bushing from the knob, if for any reason they should be combined off the instrument, drive a machine tap a turn or two into the bushing for sufficient grip for easy separation.

e. From the next bushing, remove the two setscrews, using a hex-socket key wrench; remove the bushing and dial.

f. If the switch is to be removed, remove the dress nut under the dial and remove the switch shielding "can" by removing the bracket at the end of the shielding can before removing the switch. Refer to paragraph 5.11.

g. Replace the switches by reversing the above procedure.

NOTE

Make sure that the end of the shaft does not protrude through the bushing or the knob won't set properly. If the retention spring in the knob comes loose, reinstall it in the interior notch with the small slit in the wall.

Table 5-5
FAULT SYMPTOMS AND PROBABLE CAUSES

Symptom	Probable Cause	Notes
No output and meter reading in any mode of operation. (ATTEN-ONLY mode will not give a meter indication.)	OUTPUT ON-OFF switch (S102) circuit. Check for continuity between contacts 108R and 106R.	
No output occurs for all modes, or no output occurs for a FULL SCALE OUTPUT VOLTAGE control setting, but meter gives an indication for -10-V ac, and 1-V ac modes.	120-dB output attenuator. If an output does not occur for a FULL SCALE OUTPUT VOLTAGE control (S101) setting, check the applicable portion of the 120-dB output attenuator and S101 control.	Refer to Figure 6-2 for the location of resistors in the output attenuator. Refer to paragraph 5-11 for instructions on how to gain access to the attenuator.
No output and meter reading occurs, or inaccurate output and meter reading occurs, for the -10V dc, +10V dc, 10-V ac and 1-V ac modes.	LEVEL control R101.	
Output occurs for all modes, but no meter reading occurs for ac and dc modes.	Meter movement.	
Output occurs for all modes but no meter reading occurs for ac mode.	Bridge-rectifier circuit.	
Output occurs for all modes but no meter reading occurs for dc mode.	Dc meter calibration circuit; dc portion of meter movement; S101.	
Output occurs for ac mode, but no output and meter reading occurs for dc mode, and no meter reading occurs for 1-V ac mode.	Battery circuit.	
No meter reading occurs for 10-V ac mode but outputs and meter readings for 1-V ac, -10-V dc, and +10-V dc modes occur.	10-V ac meter calibration circuit; S101.	
No meter reading occurs for 10-V ac mode, but outputs and meter readings occur for -10-V dc, +10-V dc, and 10-V ac modes, and output occurs for 1-V ac mode.	1-V ac meter-calibration circuit.	The dc voltages for transistor Q201, measured to a full-strength 12-V internal battery supply with the instrument in the 1-V ac mode, are: Collector: 7 V, ± 10 % Base: 2 V, ± 10 %
Ac meter circuit can not be calibrated.	Bridge diodes or leaky diode CR101.	Disconnect CR101 and recalibrate. If the meter can be calibrated replace CR101. If not, check the bridge diodes.

5.10.2 Level Control.

a. To remove the LEVEL control, turn the control full ccw and pull off the knob. Do not use a screwdriver or other instrument if the knob is on tight since this might mar the finish. Do not lose the retention spring in the knob when it is removed.

b. Remove the setscrew from the bushing and remove the bushing.

c. Reverse the removal procedure to replace the control.

5.11 REMOVAL OF ATTENUATOR SHIELDING.

a. Remove the front-panel METER FULL SCALE AND FULL SCALE OUTPUT VOLTAGE switches according to the procedure in paragraph 5.10.

b. Remove the bracket from the shield can.

c. Tilt the switch and remove the can.

d. Replace the switch assembly for troubleshooting.

e. Replace the can by reversing steps a through c.

5.12 BATTERY REPLACEMENT.

To install a new battery, remove the clip-leads from the battery, loosen the screws holding the clamps and slide the old battery out of the clamps. Slide the new battery into the clamps with the positive end of the battery facing the front panel. The clamps may have to be reshaped slightly to accept the battery. Attach (clip-on) the battery leads; the orange and white lead is the positive connection.

5.13 FRONT-PANEL FINISH.

If the front-panel is marred or scratched, touch-up with light-gray colored paint, conforming with Federal Standard 595 (gray, 26492).

Parts Lists and Diagrams–Section 6

6.1 GENERAL.

This section contains the replaceable-parts lists, schematics, and etched-board layout. The Federal manufacture's code numbers in the parts lists are identified in the "Federal Manufacturers Code" listing. Figure 6-1 shows a front view of the Type 1346, identifying parts. Figure 5-2 shows an interior view, identifying parts.

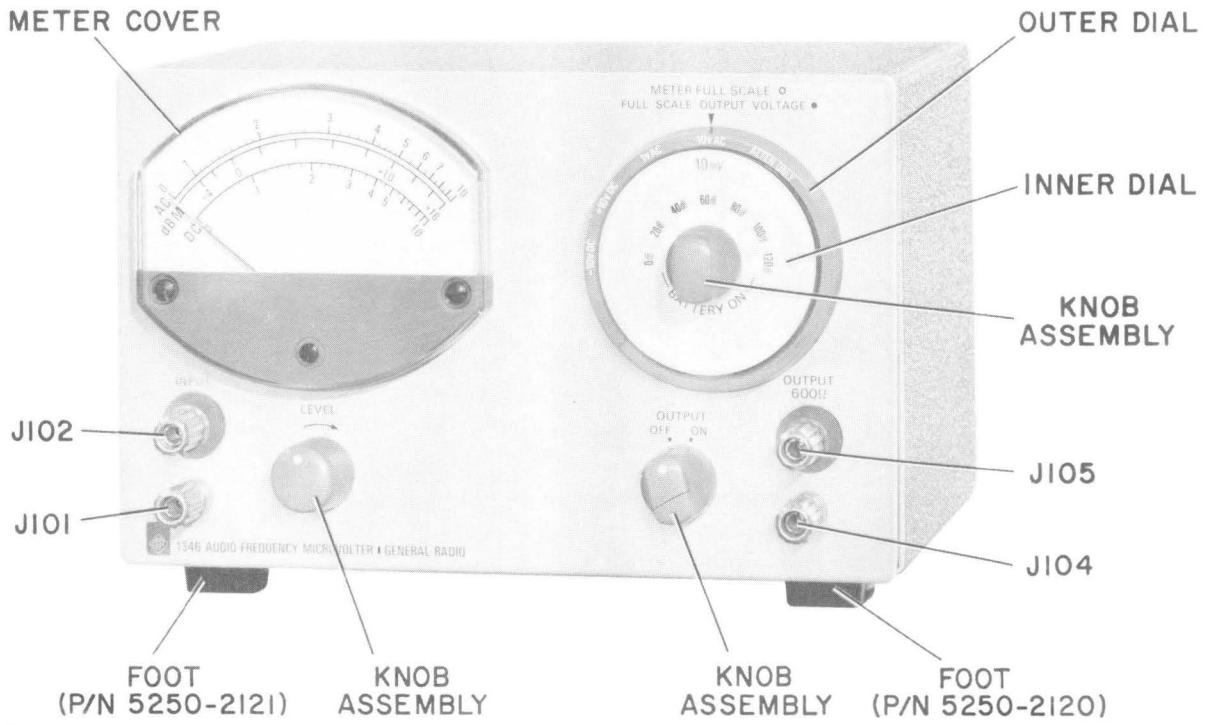
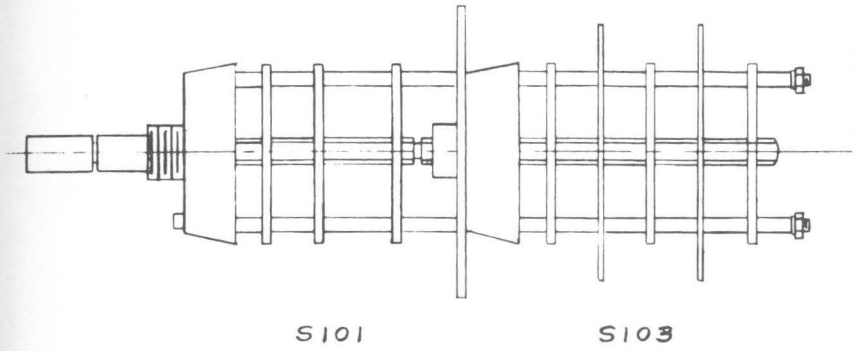


Figure 6-1. Front view of the Type 1346 Microvolter.

MECHANICAL REPLACEABLE PARTS

Description	GR Part No.	Fed. Mfg. Code	Mfg. Part No.
DIAL ASSEMBLIES			
Meter Full Scale, Inner Dial	1346-1020	24655	1346-1020
Meter Full Scale, Outer Dial	1346-2000	24655	1346-2000
KNOB ASSEMBLIES			
OUTPUT	5500-5221	24655	5500-5221
METER FULL SCALE	5500-5220	24655	5500-5520
LEVEL	5520-5221	24655	5520-5221
CABINET, CONVERTIBLE-BENCH	4181-3624	24655	4181-3624
Hardware Set	4181-1111	24655	4181-1111
Foot	5250-2120	24655	5250-2120
Foot	5250-2121	24655	5250-2121
Bail	5250-2123	24655	5250-2123
Foot	5260-2060	24655	5260-2060
O Ring, Retaining Screw	5855-0156	24655	5855-0156
Screw, Cabinet Retaining	7098-0200	24655	7198-0200
ETCHED-CIRCUIT-BOARD ASSY	1346-2710	24655	1346-2710
METER COVER	5720-3714	91929	ME3-701

7890-5090



NOTE:

This diagram is a layout of switches S101 and S103, showing the locations of the output attenuator components and their connections. The inner circle represents switch section 1 of S101 and the fourth circle from the inside switch section 1 of S103. Refer to the note in Figure 6-3 for a description of the switch, if necessary.

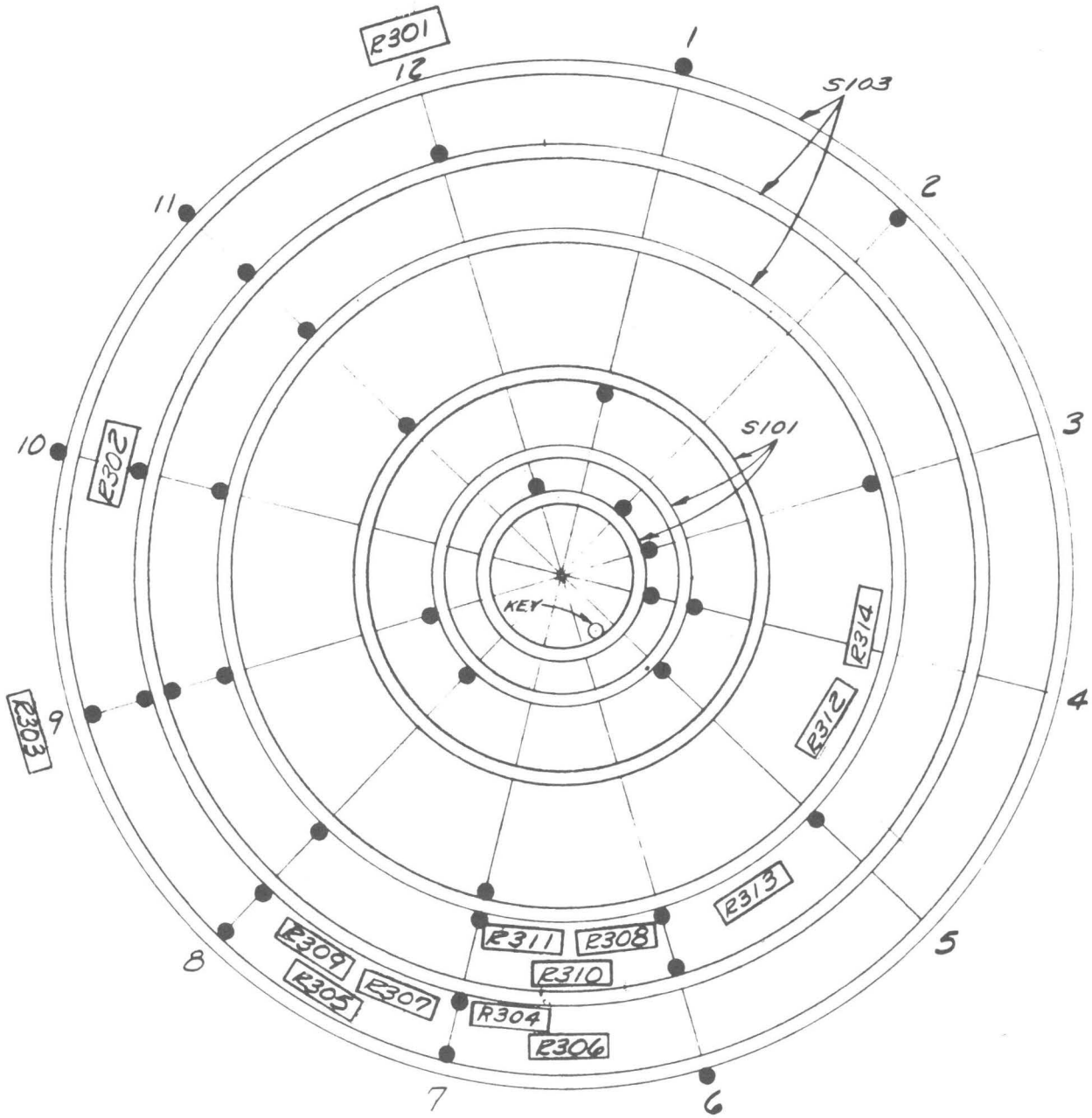
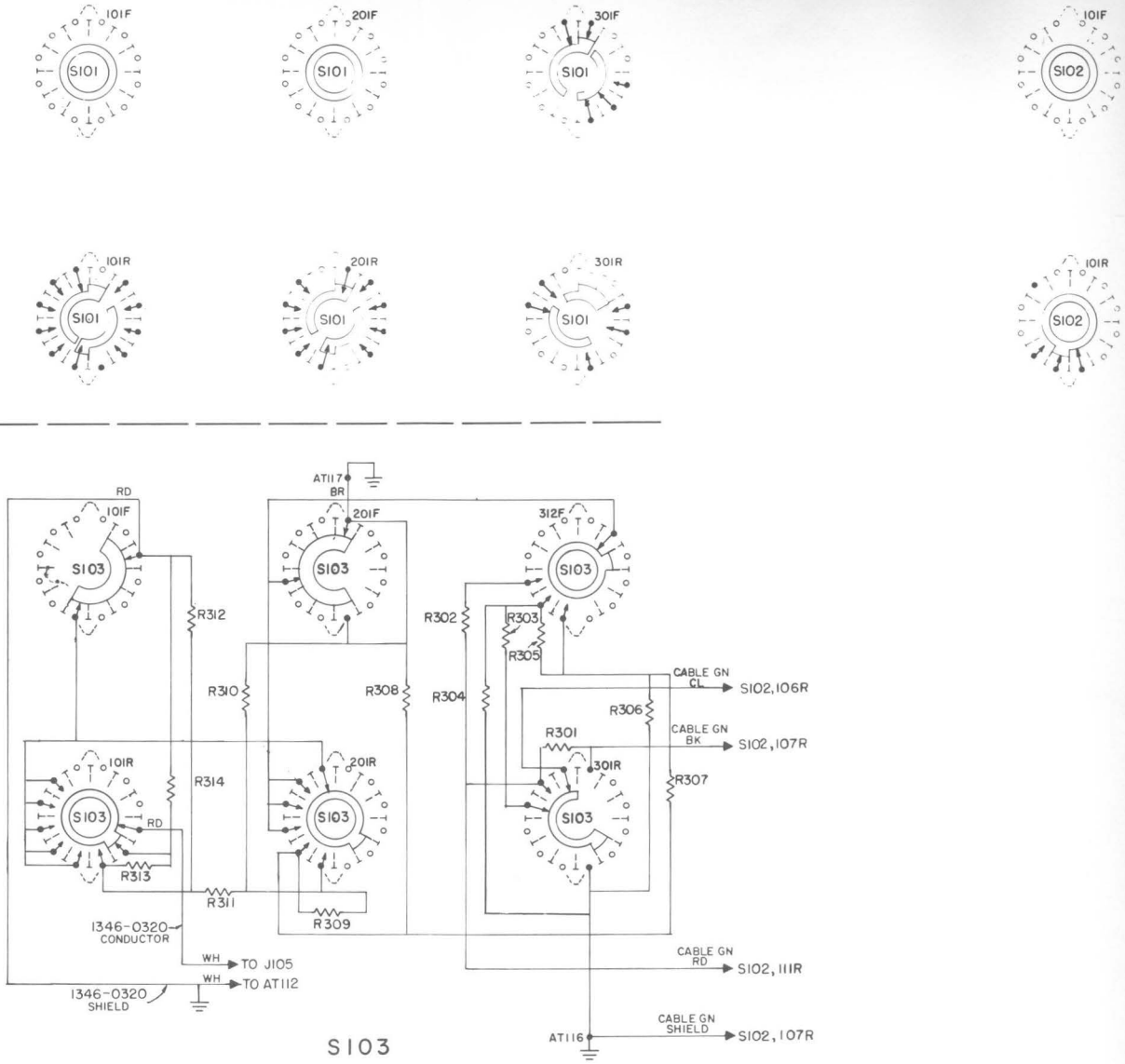


Figure 6-2. Output attenuator diagram showing component locations.



S103

NOTE:

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

Figure 6-3. Schematic of meter full scale and full scale output voltage switches.

ELECTRICAL REPLACEABLE PARTS

Ref. Desig.	Description	GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C201	Trimmer 1.5-7pF NPO	4910-1110	72982	557-051, U2PO 1.5 to 7pF	
C202	Electrolytic 40μF 6V	4450-3600	37942	20-40707S4	5910-952-0467
C203	Electrolytic 220μF ±20% 10V	4450-5706	37942	TT 220μF ±20%	
C204	Ceramic 2.2pF ±5% 500V	4400-0205	78488	GA, 2.2pF ±5%	5910-667-6114
C205	Ceramic 75pF ±5% 500V	4404-0755	72982	831, 75pF ±5%	
DIODES					
CR101	Type 1N4009	6082-1012	24446	1N4009	
CR201	Type 1N695	6082-1014	24446	1N695	5961-892-8700
CR202	Type 1N695	6082-1014	24446	1N695	
CR203	Type 1N695	6082-1014	24446	1N695	
CR204	Type 1N695	6082-1014	24446	1N695	
JACKS					
J101	Binding Post	0938-2022	24655	0938-2022	5940-912-0008
J102	Binding Post	4060-0108	24655	4060-0108	5905-912-0007
J103	Connector, BNC	4230-2301	09408	UG - 1094 A/U	
J104	Binding Post	0938-2022	24655	0938-2022	5940-912-0008
J105	Binding Post	4060-0108	24655	4060-0108	5905-912-0007
J106	Connector, BNC	4230-2301	09408	UG - 1094 A/U	
METER					
M101		5730-1405	65092	Type 1907	
RESISTORS					
R101	Pot., Comp. 25KΩ ±10%	6048-3259	01121	JA, 25KΩ ±10%	
R201	Composition 33KΩ ±5% 1/4W	6099-3335	75042	BTS, 33KΩ ±5%	
R202	Pot., Comp. 5KΩ ±20%	6040-0600	01121	FWC, 5KΩ ±20%	5905-034-5374
R203	Composition 16KΩ ±5% 1/4W	6099-3165	75042	BTS, 16KΩ ±5%	
R204	Composition 82KΩ ±5% 1/4W	6099-3825	75042	BTS, 82KΩ ±5%	
R205	Composition 20KΩ ±5% 1/4W	6099-3205	75042	BTS, 20KΩ ±5%	5905-686-3368
R206	Composition 12KΩ ±5% 1/4W	6099-3125	75042	BTS, 12KΩ ±5%	
R207	Composition 3.3KΩ ±5% 1/4W	6099-2335	75042	BTS, 3.3KΩ ±5%	5905-681-9969
R208	Pot., Comp. 500Ω ±20%	6040-0300	01121	FWC, 500Ω ±20%	5905-072-7795
R209	Composition 47KΩ ±5% 1/4W	6099-3475	75042	BTS, 47KΩ ±5%	5905-683-2246
R210	Pot., Comp. 10KΩ ±20%	6040-0700	01121	FWC, 10KΩ ±20%	5905-549-2773

ELECTRICAL REPLACEABLE PARTS (Cont.)

Ref. Desig	Description	GR Part No.	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS (Cont.)					
R301	Film 6.65KΩ ±¼% 1/4W	6352-1665	75042	CEB, 6.65KΩ ±¼%	
R302	Film 600Ω ±¼% 1/4W	6352-0600	75042	CEB, 600Ω ±¼%	
R303	Film 6KΩ ±¼% 1/8W	6252-1600	75042	CEA, 6KΩ ±¼%	
R304	Film 742Ω ±¼% 1/8W	6252-0742	75042	CEA, 742Ω ±¼%	
R305	Film 5.94KΩ ±¼% 1/8W	6252-1594	75042	CEA, 5.94KΩ ±¼%	
R306	Film 733Ω ±¼% 1/8W	6252-0733	75042	CEA, 733Ω ±¼%	
R307	Film 5.94KΩ ±¼% 1/8W	6252-1594	75042	CEA, 5.94KΩ ±¼%	
R308	Film 733Ω ±¼% 1/8W	6252-0733	75042	CEA, 733Ω ±¼%	
R309	Film 5.94KΩ ±¼% 1/8W	6252-1594	75042	CEA, 5.94KΩ ±¼%	
R310	Film 733Ω ±¼% 1/8W	6252-0733	75042	CEA, 733Ω ±¼%	
R311	Film 5.94KΩ ±¼% 1/8W	6252-1594	75042	CEA, 5.94KΩ ±¼%	
R312	Film 733Ω ±¼% 1/8W	6252-0733	75042	CEA, 733Ω ±¼%	
R313	Film 5.94KΩ ±¼% 1/8W	6252-1594	75042	CEA, 5.94KΩ ±¼%	
R314	Film 660Ω ±¼% 1/8W	6252-0660	75042	CEA, 660Ω ±¼%	
SWITCHES					
S101	Rotary Wafer	7890-5090	24655	7890-5090	
S102	Rotary Wafer	7890-5080	24655	7890-5080	
TRANSIS-TORS					
Q201	Type 2N3903	8210-1132	93916	2N3903	

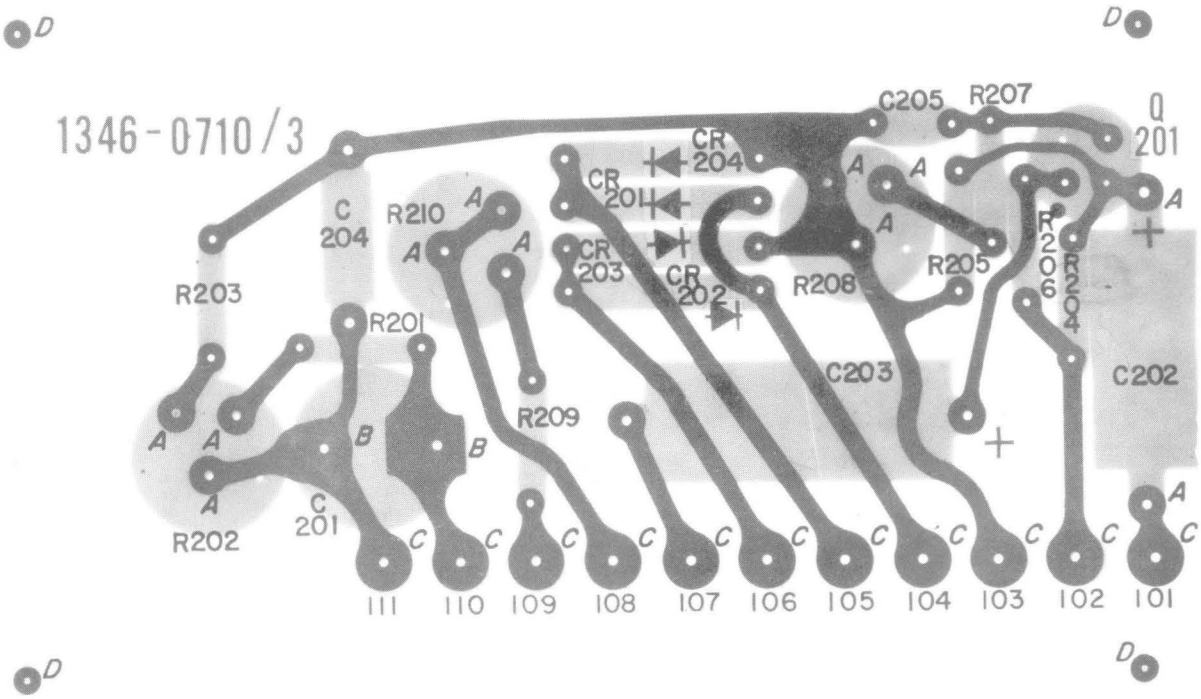
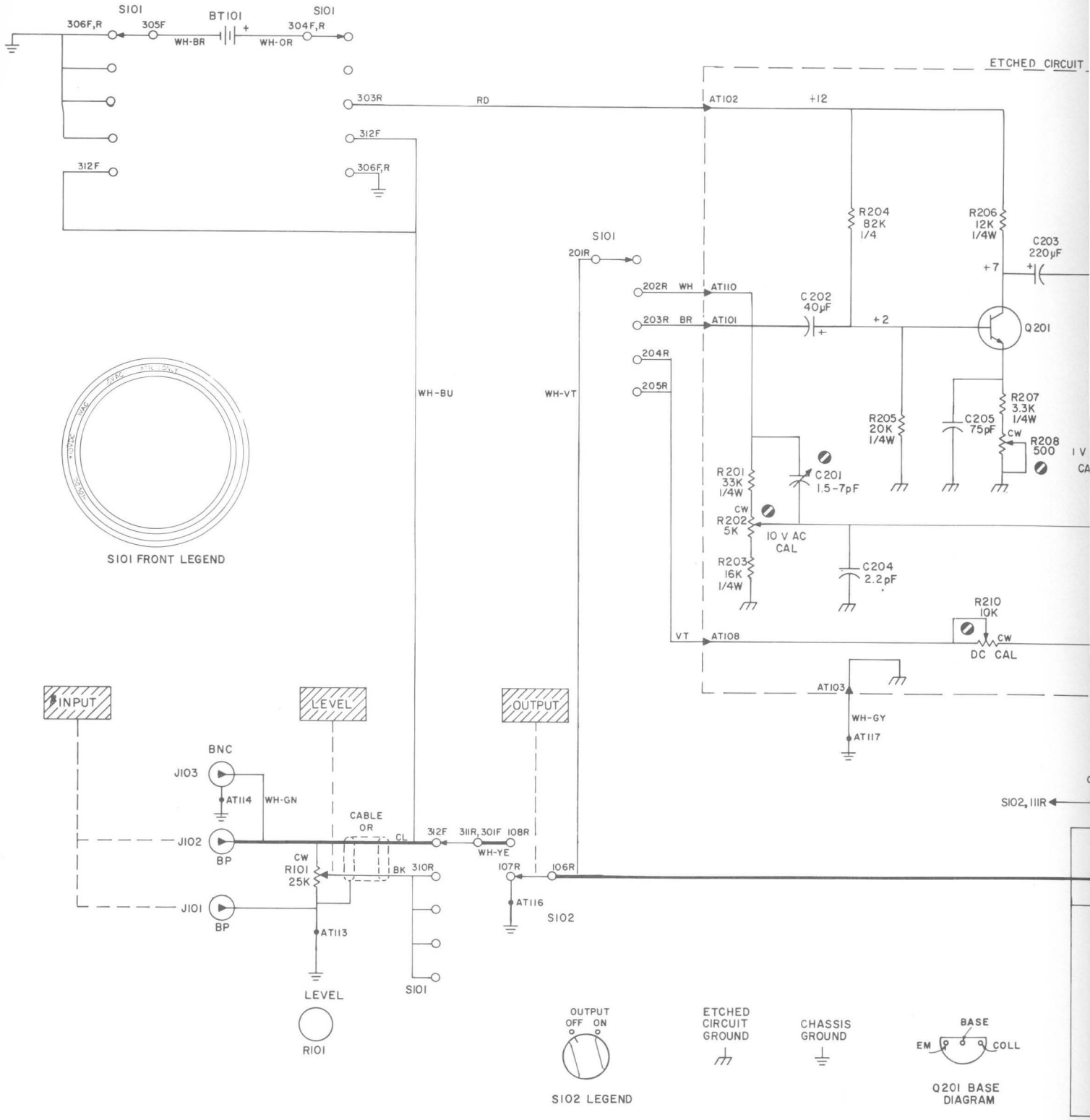


Figure 6-4. Etched-circuit board assembly (P/N 1346-2710)

NOTE

The number shown on the foil side of the board is not the part number for the complete assembly. This assembly is given in the caption.

The dot on the foil at the transistor socket indicates the collector lead.



NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/8 WATT.
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

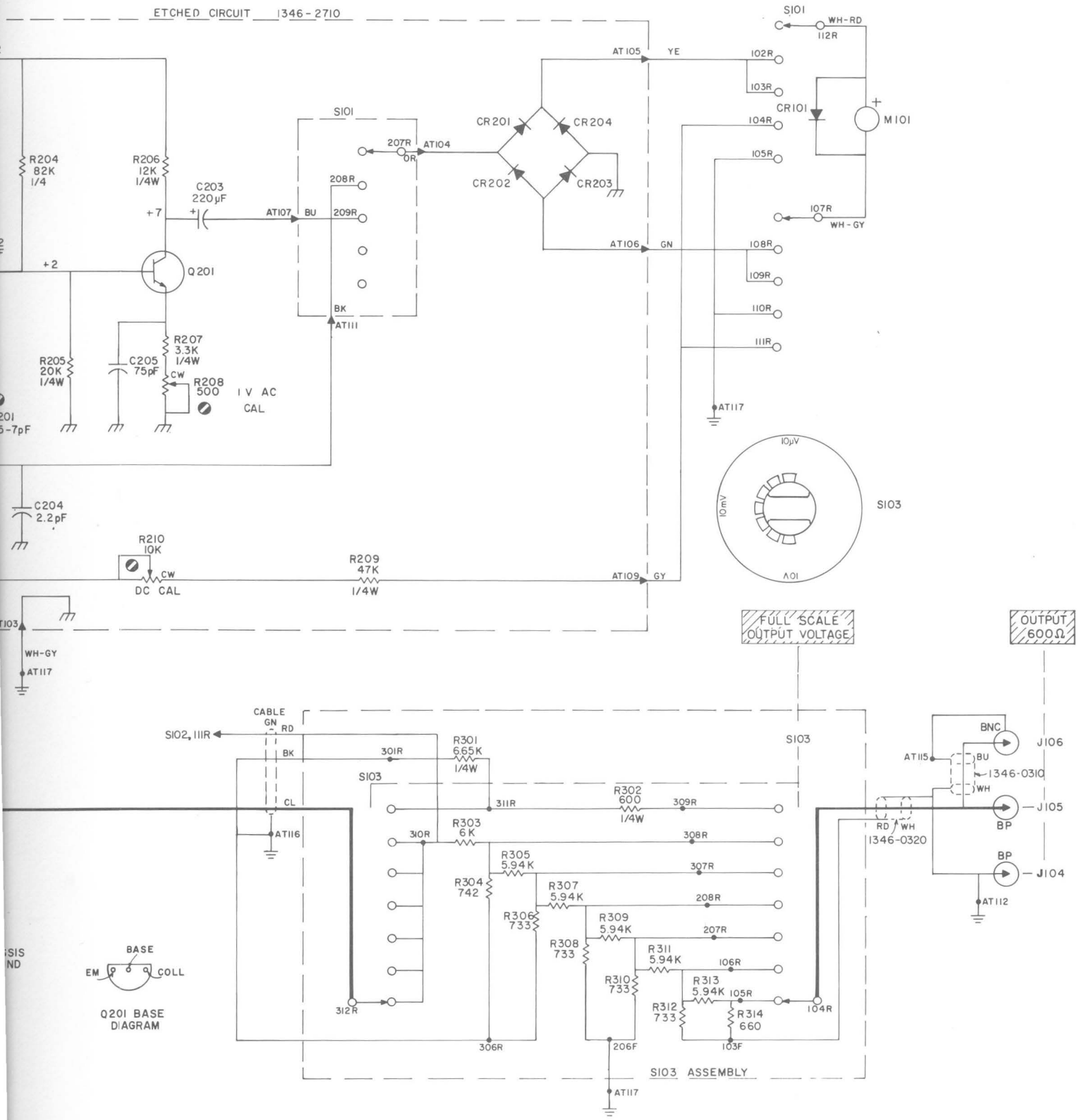


Figure 6-5. Type 1346 Audio-Frequency Microvolter schematic.

FEDERAL MANUFACTURER'S CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through August, 1968.

Code	Manufacturer
00192	Jones Mfg. Co, Chicago, Illinois
00194	Walsco Electronics Corp, L.A., Calif.
00434	Schweber Electronics, Westburg, L.I., N.Y.
00656	Aerovox Corp, New Bedford, Mass.
01009	Alden Products Co, Brockton, Mass.
01121	Allen-Bradley, Co, Milwaukee, Wisc.
01295	Texas Instruments, Inc, Dallas, Texas
02114	Ferroxcube Corp, Saugerties, N.Y. 12477
02606	Fenwal Lab Inc, Morton Grove, Ill.
02660	Amphenol Electron Corp, Broadview, Ill.
02768	Fastex, Des Plaines, Ill. 60016
03508	G.E. Semicon Prod, Syracuse, N.Y. 13201
03636	Grayburne, Yonkers, N.Y. 10701
03888	Pyrofilm Resistor Co, Cedar Knolls, N.J.
03911	Clairex Corp, New York, N.Y. 10001
04009	Arrow-Hart & Hegeman, Hartford, Conn. 06106
04713	Motorola, Phoenix, Ariz. 85008
05170	Engr'd Electronics, Santa Ana, Calif. 92702
05624	Barber-Colman Co, Rockford, Ill. 61101
05820	Wakefield Eng, Inc, Wakefield, Mass. 01880
07126	Digitron Co, Pasadena, Calif.
07127	Eagle Signal (E.W. Bliss Co), Baraboo, Wisc.
07261	Avnet Corp, Culver City, Calif. 90230
07263	Fairchild Camera, Mountain View, Calif.
07387	Birtcher Corp, No. Los Angeles, Calif.
07595	Amer Semicond, Arlington Hts, Ill. 60004
07828	Bodine Corp, Bridgeport, Conn. 06605
07829	Bodine Electric Co, Chicago, Ill. 60618
07910	Cont Device Corp, Hawthorne, Calif.
07983	State Labs Inc, N.Y., N.Y. 10003
07999	Borg Inst., Delavan, Wisc. 53115
08730	Vemaline Prod Co, Franklin Lakes, N.J.
09213	G.E. Semiconductor, Buffalo, N.Y.
09408	Star-Tronics Inc, Georgetown, Mass. 01830
09823	Burgess Battery Co, Freeport, Ill.
09922	Burndy Corp, Norwalk, Conn. 06852
11236	C.T.S. of Berne, Inc, Berne, Ind. 46711
11599	Chandler Evans Corp, W. Hartford, Conn.
12040	National Semiconductor, Danbury, Conn.
12498	Crystalonics, Cambridge, Mass. 02140
12672	RCA, Woodbridge, N.J.
12697	Clarostat Mfg Co, Inc, Dover, N.H. 03820
12954	Dickson Electronics, Scottsdale, Ariz.
13327	Solitron Devices, Tappan, N.Y. 10983
14433	ITT Semicondictors, W.Palm Beach, Fla.
14655	Cornell-Dubilier Electric Co, Newark, N.J.
14674	Corning Glass Works, Corning, N.Y.
14936	General Instrument Corp, Hicksville, N.Y.
15238	ITT, Semiconductor Div, Lawrence, Mass.
15605	Cutler-Hammer Inc, Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co, Spruce Pine, N.C.
17771	Singer Co, Diehl Div, Somerville, N.J.
19396	Illinois Tool Works, Pakton Div, Chicago, Ill.
19644	LRC Electronics, Horseheads, N.Y.
19701	Electra Mfg Co, Independence, Kansas 67301
21335	Fafnir Bearing Co, New Briton, Conn.
22753	UID Electronics Corp, Hollywood, Fla.
23342	Avnet Electronics Corp, Franklin Park, Ill.
24446	G.E., Schenectady, N.Y. 12305
24454	G.E., Electronics Comp, Syracuse, N.Y.
24455	G.E. (Lamp Div), Nela Park, Cleveland, Ohio
24655	General Radio Co, W. Concord, Mass. 01781
26806	American Zettlet Inc, Costa Mesa, Calif.
28520	Hayman Mfg Co, Kenilworth, N.J.
28959	Hoffman Electronics Corp, El Monte, Calif.
30874	I.B.M, Armonk, New York
32001	Jensen Mfg. Co, Chicago, Ill. 60638
33173	G.E. Comp, Owensboro, Ky. 42301
35929	Constanta Co, Mont. 19, Que.
37942	P.R. Mallory & Co Inc, Indianapolis, Ind.
38443	Marlin-Rockwell Corp, Jamestown, N.Y.
40931	Honeywell Inc, Minneapolis, Minn. 55408
42190	Muter Co, Chicago, Ill. 60638
42498	National Co, Inc, Melrose, Mass. 02176
43991	Norma-Hoffman, Stanford, Conn. 06904
49671	RCA, New York, N.Y. 10020
49956	Raytheon Mfg Co, Waltham, Mass. 02154
53021	Sangamo Electric Co, Springfield, Ill. 62705
54294	Shallcross Mfg Co, Selma, N.C.
54715	Shure Brothers, Inc, Evanston, Ill.
56289	Sprague Electric Co, N. Adams, Mass.
59730	Thomas and Betts Co, Elizabeth, N.J. 07207
59875	TRW Inc, (Accessories Div), Cleveland, Ohio
60399	Torrington Mfg Co, Torrington, Conn.
61637	Union Carbide Corp, New York, N.Y. 10017
61864	United-Carr Fastener Corp, Boston, Mass.
63060	Victoreen Instrument Co, Inc, Cleveland, O.
63743	Ward Leonard Electric Co, Mt. Vernon, N.Y.
65083	Westinghouse (Lamp Div), Bloomfield, N.J.
65092	Weston Instruments, Newark, N.J.
70485	Atlantic-India Rubber, Chicago, Ill. 60607
70563	Amperite Co, Union City, N.J. 07087
70903	Belden Mfg Co, Chicago, Ill. 60644
71126	Bronson, Homer D, Co, Beacon Falls, Conn.
71294	Canfield, H.O. Co, Clifton Forge, Va. 24422
71400	Bussman (McGraw Edison), St. Louis, Mo.
71468	ITT Cannon Elec, L.A., Calif. 90031
71590	Centralab, Inc, Milwaukee, Wisc. 53212
71666	Continental Carbon Co, Inc, New York, N.Y.
71707	Coto Coil Co Inc, Providence, R.I.
71744	Chicago Miniature Lamp Works, Chicago, Ill.
71785	Cinch Mfg Co, Chicago, Ill. 60624
71823	Darnell Corp, Ltd, Downey, Calif. 90241
72136	Electro Motive Mfg Co, Wilmington, Conn.
72259	Nytronics Inc, Berkeley Heights, N.J. 07922
72619	Dialight Co, Brooklyn, N.Y. 11237
72699	General Instr Corp, Newark, N.J. 07104
72765	Drake Mfg Co, Chicago, Ill. 60656
72825	Hugh H. Eby Inc, Philadelphia, Penn. 19144
72962	Elastic Stop Nut Corp, Union, N.J. 07083
72982	Erie Technological Products Inc, Erie, Penn.
73138	Beckman Inc, Fullerton, Calif. 92634
73445	Amperex Electronics Co, Hicksville, N.Y.
73559	Carling Electric Co, W.Hartford, Conn.
73690	Elco Resistor Co, New York, N.Y.
73899	JFD Electronics Corp, Brooklyn, N.Y.
74193	Heinemann Electric Co, Trenton, N.J.
74861	Industrial Condenser Corp, Chicago, Ill.
74970	E.F. Johnson Co, Waseca, Minn. 56093
75042	IRC Inc, Philadelphia, Penn. 19108
75382	Kulka Electric Corp, Mt. Vernon, N.Y.
75491	Lafayette Industrial Electronics, Jamica, N.Y.
75608	Linden and Co, Providence, R.I.
75915	Littelfuse, Inc, Des Plaines, Ill. 60016
76005	Lord Mfg Co, Erie, Penn. 16512
76149	Mallory Electric Corp, Detroit, Mich. 48204
76487	James Millen Mfg Co, Malden, Mass. 02148
76545	Mueller Electric Co, Cleveland, Ohio 44114
76684	National Tube Co, Pittsburg, Penn.
76854	Oak Mfg Co, Crystal Lake, Ill.
77147	Patton MacGuyer Co, Providence, R.I.
77166	Pass-Seymour, Syracuse, N.Y.
77263	Pierce Roberts Rubber Co, Trenton, N.J.
77339	Positive Lockwasher Co, Newark, N.J.
77642	Ray-O-Vac Co, Madison, Wisc.
77630	TRW, Electronic Comp, Camden, N.J. 08103
77638	General Instruments Corp, Brooklyn, N.Y.
78189	Shakeproof (Ill. Tool Works), Elgin, Ill. 60120
78277	Sigma Instruments Inc, S.Braintree, Mass.
78488	Stackpole Carbon Co, St. Marys, Penn.
78553	Tinnerman Products, Inc, Cleveland, Ohio
79089	RCA, Rec Tube & Semicond, Harrison, N.J.
79725	Wiremold Co, Hartford, Conn. 06110
79963	Zierick Mfg Co, New Rochelle, N.Y.
80030	Prestole Fastener, Toledo, Ohio
80048	Vickers Inc, St. Louis, Mo.
80131	Electronic Industries Assoc, Washington, D.C.
80183	Sprague Products Co, No. Adams, Mass.
80211	Motorola Inc, Franklin Park, Ill. 60131
80258	Standard Oil Co, Lafeyette, Ind.
80294	Bourns Inc, Riverside, Calif. 92506
80431	Air Filter Corp, Milwaukee, Wisc. 53218
80583	Hammarlund Co, Inc, New York, N.Y.
80740	Beckman Instruments, Inc, Fullerton, Calif.
81030	International Insturment, Orange, Conn.
81073	Grayhill Inc, LaGrange, Ill. 60525
81143	Isolantite Mfg Corp, Stirling, N.J. 07980
81349	Military Specifications
81350	Joint Army-Navy Specifications
81751	Columbus Electronics Corp, Yonkers, N.Y.
81831	Filtron Co, Flushing, L.I., N.Y. 11354
81840	Ledex Inc, Dayton, Ohio 45402
81860	Barry-Wright Corp, Watertown, Mass.
82219	Sylvania Elec Prod, Emporium, Penn.
82273	Indiana Pattern & Model Works, LaPort, Ind.
82389	Switchcraft Inc, Chicago, Ill. 60630
82647	Metals & Controls Inc, Attleboro, Mass.
82807	Milwaukee Resistor Co, Milwaukee, Wisc.
83033	Meissner Mfg, (Maguire Ind) Mt. Carmel, Ill.
83058	Carr Fastener Co, Cambridge, Mass.
83186	Victory Engineering, Springfield, N.J. 07081
83361	Bearing Specialty Co, San Francisco, Calif.
83587	Solar Electric Corp, Warren, Penn.
83740	Union Carbide Corp, New York, N.Y. 10017
83781	National Electronics Inc, Geneva, Ill.
84411	TRW Capacitor Div, Ogallala, Nebr.
84835	Lehigh Metal Prods, Cambridge, Mass. 02140
84971	TA Mfg Corp, Los Angeles, Calif.
86577	Precision Metal Prods, Stoneham, Mass. 02180
86684	RCA (Elect. Comp & Dev), Harrison, N.J.
86687	REC Corp, New Rochelle, N.Y. 10801
86800	Cont Electronics Corp, Brooklyn, N.Y. 11222
88140	Cutler-Hammer Inc, Lincoln, Ill.
88219	Gould Nat. Batteries Inc, Trenton, N.J.
88419	Cornell-Dubilier, Fuquay-Varina, N.C.
88627	K & G Mfg Co, New York, N.Y.
89482	Holtzer-Cabot Corp, Boston, Mass.
89665	United Transformer Co, Chicago, Ill.
90201	Mallory Capacitor Co, Indianapolis, Ind.
90750	Westinghouse Electric Corp, Boston, Mass.
90952	Hardware Products Co, Reading, Penn. 19602
91032	Continental Wire Corp, York, Penn. 17405
91146	ITT (Cannon Electric Inc), Salem, Mass.
91293	Johanson Mfg Co, Boonton, N.J. 07005
91506	Augat Inc, Attleboro, Mass. 02703
91598	Chandler Co, Wethersfield, Conn. 06109
91637	Dale Electronics Inc, Columbus, Nebr.
91662	Elco Corp, Willow Grove, Penn.
91719	General Instruments, Inc, Dallas, Texas
91929	Honeywell Inc, Freeport, Ill.
92519	Electra Insul Corp, Woodside, L.I., N.Y.
92678	E.G.&G., Boston, Mass.
93332	Sylvania Elect Prods, Inc, Woburn, Mass.
93916	Cramer Products Co, New York, N.Y. 10013
94144	Raytheon Co, Components Div, Quincy, Mass.
94154	Tung Sol Electric Inc, Newark, N.J.
95076	Garde Mfg Co, Cumberland, R.I.
95121	Quality Components Inc, St. Mary's, Penn.
95146	Alco Electronics Mfg Co, Lawrence, Mass.
95238	Continental Connector Corp, Woodside, N.Y.
95275	Vitramon, Inc, Bridgeport, Conn.
95354	Methode Mfg Co, Chicago, Ill.
95412	General Electric Co, Schenectady, N.Y.
95794	Anaconda Amer Brass Co, Torrington, Conn.
96095	Hi-Q Div. of Aerovox Corp, Orlean, N.Y.
96214	Texas Instruments Inc, Dallas, Texas 75209
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General Radio Company (Overseas), 8008 Zurich, Switzerland
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